PROGRAMMING AND EXECUTION OF THERMODYNAMIC LAWS USING C++ & 8085 MICROPROCESSOR

PROJECT REPORT

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in partial fulfillment of the requirement for the award of

BACHELOR'S DEGREE IN PHYSICS

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CERTIFICATE

This is to certify that the project work entitled "PROGRAMMING AND EXECUTION OF THERMODYNAMIC LAWS USING C++ & 8085 MICROPROCESSOR" is submitted to St. Mary's College (Autonomous), Thoothukudi, in partial fulfillment for the award of the Bachelor's Degree in Physics and is a record of work done during the year 2021-2022 by the following students.

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ABSTRACT

C++ and Microprocessor have wide applications in the field of Physics. One of the most important applications is simplification of equation. It requires less time compared to manual calculations for solving equations. Thermodynamics is a field of physics that studies the relationship between heat, work, temperature and energy. Thermodynamics finds its application in automotive engines, rockets, jet engines nuclear power plants, solar collectors, and the design of vehicles from ordinary cars to airplanes. Therefore, solving thermodynamics problems using C++ and Microprocessor 8085 is significant. In this study the first and second law of thermodynamics are solved using C++ and Microprocessor. This study observes that we can solve statement problems by giving various inputs. The outputs are tabulated and graphs are drawn to compare the results and validate the proposed method.

Correction Orientes Programming

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CHAPTER - I

CHAPTER - I

INTRODUCTION

1.1 Thermodynamics

The word "Thermodynamics" was derived from the Greek words thermos (heat) and dynamics (force).

Thermodynamics is from the Greek root meaning movement of heat. 'Sadi Carnot' the father of thermodynamics, who in 1824 published reflections on the motive power of fire, discourse on heat, power and engine efficiency. This marks the start of thermodynamics as a modern science.

Thermodynamics give the foundation for heat engines, powerplants, chemical reactions, refrigerator and many more important concepts that the world we live in today relies on.

Thermodynamics are used in internal combustion engines, propulsion system, Astrophysics, atmosphere and climate.

The derivations are solved quick and easily by changing the inputs in C++ and Microprocessor.

In first law of thermodynamics, the final temperature after work done of an ideal monoatomic gas can be solved quickly.

In second law of thermodynamics, availability of heat can be determined instantly.

1.2 C++

C++ a high-level computer programming language was developed by Bjarne Stroustrup of Bell Laboratories in the early 1980s, it is based on the traditional C language but with added object-oriented programming and other capabilities.

Bjarne Stroustrup thought to combine the simplicity of a low-level language and the concept of classes in a single language. C++ was initially known as C with classes.

C++ helps in optimizing the resources. It supports the multiplayer option with networking. C++ allows procedural programming for intensive functions of CPU and

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to provide control over hardware, and this language is very fast because of which it is widely used in developing different games or in gaming engines.

C++ is used for a large number of applications within industry and Particle Physics research. The language provides a large amount of functionality and is still being extended. This course focuses on core aspects of C++ and expects the reader will consult reading materials to extend this introduction.

1.3 Microprocessor

8085 is pronounced as "eighty-eighty-five" microprocessor. It is an 8-bit microprocessor designed by Intel in 1977 using NMOS technology.

The evolution of microprocessor 8085 is known as a **Central Processing Unit** (CPU). It is a complete computation engine that is fabricated on a single chip.

The first microprocessor was the Intel 4004, introduced in 1971. The 4004 is a 4-bit processor. The 8085 microprocessor is an 8-bit general purpose microprocessor which is capable to address 64k of memory. This processor has forty pins, requires +5 V single power supply and a 3-MHz single-phase clock. An ALU performs the computing function of microprocessor. Accumulator is an 8-bit register that is part of ALU. This register is used to store 8-bit data & in performing arithmetic & logic operation. Flags are programmable. They can be used to store and transfer the data from the registers by using instruction. And registers are used to storage purposes normally program counter, stack are used as storage registers.

The reason for saying these components in 8085 is that these are fundamental components that are used in successor microprocessors of 8085.8085 is regarded as the mother of CPU design and all other microprocessors are enhancement of 8085. Intel 8080 is the enhanced design of 8008 which lacked binary compatible. Successor of 8080 is 8085 which is binary compatible with 8080 and successor of 8085 is 8086 and successor of 8086 is 8088.

By using Microprocessor instructions, we can solve large number of problems.

1.4 Aim of the project

- To choose and solve a statement problem which employs equations of thermodynamics.
- To write a C++ and 8085 Microprocessor program to solve the chosen problem.
- To change the inputs of the program and obtain a tabulation.
- To analyse the tabulation and draw a graph.

CHAPTER -II

CHAPTER - II

LITERATURE REVIEW

Evelyn Guha [1] has a clear view on the evolution and growth of thermodynamics. Thermodynamics the study of the relation between heat work and energy. Appliances like Refrigerators, air conditioners are based on the principle of thermodynamics laws. These appliances play an essential role in today's era.

A.B. Gupta and H.P. Roy [2] briefly explains the key concept of thermodynamics is that heat is a form of energy corresponding to a definite amount of mechanical work. He also gave a detail explanation on the laws of thermodynamics, properties and applications based on these laws.

H.M Deital and P.J. Deital [3] presents a through treatment of procedural Programming in C++ including data types input or output control structures functions, arrays, pointers and strings. A substantial treatment of data abstraction with classes, objectives and operator overloading. This section might effectively be called program with object this also presents inheritance virtual functions and polymorphism-The root technologies of true object-oriented programming with object.

E. Balagurusamy [4] gave a detail idea on programming with C++. C++ an objectoriented programming language is the preferred programming language in the software world. An object-oriented programming language should include concepts of class object, Data abstraction, data encapsulation, inheritance, polymorphism these such concepts are included in C++. His book gives a detail explanation of classes with objects, a class specification includes class declaration and function definition. The concept of C++ plays an important role in this digital world.

Kimasha Borah [5] has an overview of microprocessor and its applications. Microprocessor is a program-controlled semiconductor device which fetches decodes and execute information. Microprocessor have day today application in equipment like DVD players, test instruments, audio visual components and smoke alarm. Due to wide variety of uses it has revolutionized to human civilization

Krishna Kant [6] gives us clear knowledge on Programming and interfacing using 8085 provides full coverage of basic topics with in-depth treatment of Architecture, Programming and interfacing concepts related to Microprocessor and

Microcontroller. Numerous Assembly Language Program and a variety of theoretical and multiple-choice questions help students check and enhance their conceptual understanding.

Samir G. Pandya's [7] provides an understanding of Microprocessor, digital computer, History and evolution of Microprocessor, Applications, Number Systems Understanding, Architecture, Block and pin diagram, instructions Cycle, Microprocessor Classification, Instruction set & Finally its Assembly Language Programming in Microprocessor.

A. Nagoor kani [8] 8085 Microprocessor and its applications attempts explain the basic concepts of programming and interfacing techniques using INTEL8085 microprocessor. In view of the complex nature of topics, the author has designed the book as a self-study material for the students in his signature style. The chapter discuss the concepts using examples and programs.

Ajay Wadhwa [9] This book is designed as a first-level introduction to Microprocessor 8085, covering its architecture, programming and interfacing aspects. Microprocessor 8085 is the basic processor from which machine language programming can be learnt. The text offers a comprehensive treatment of microprocessor's hardware and software.

Ramesh Gaonkar [10] Microprocessor architecture, programming and applications with the 8085 focuses on 8085 microprocessor family to teach the basic concept of programmable devices. Providing explanations from fundamentals to applications, the book prepares the readers to apply various concepts in their jobs related to microprocessors.

The book is divided into three parts. The first part is called Microprocessor Based Systems: Hardware and Interfacing. This part covers the topics Microprocessors, Microcomputer and Assembly Language; Introduction to 8085 Assembly Language Programming; Microprocessor Architecture and Microcomputer Systems; 8085 Microprocessor Architecture and Memory Interfacing and Interfacing I/O Devices. Part two is called Programming the 8085. It covers Introduction to 8085 Instructions, Programming Techniques with Additional Instructions, Counter and Time Delays, Stack and Subroutines, Code Conversion BCD Arithmetic and 16-Bit Data Operations and Software Development System and Assemblers. The third part is called

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Interfacing Peripherals (I/O) and Applications. It covers Interrupts, Interfacing Data Converters, Programmable Interface Devices, General Purpose Programmable Peripheral Devices, Serial I/O and Data Communication, Microprocessor Applications and Extending 8-Bit Microprocessor Concepts to higher Level Processor and Microcontrollers. This 5th edition is published in paperback, on 1st December, 2000.

Herbert Schildt [11] Genius Herb Schildt covers everything from keywords, syntax and libraries to advanced features such as overloading, inheritance, virtual functions, name spaces, templates and RTTI, plus, a complete description of the standard template library.

Robert Lafore [12] Object Oriented Programming in C++ is a comprehensive solution for teaching object-oriented programming using the features of ANSI/ISO C++. It covers the basic concepts of object-oriented programming, why those concepts exist and how to make them work effectively. The Fourth Edition is updated and revised to include more UML coverage, inter-file communication and use-cases analysis to explain software design. The book covers object-oriented programming through task-oriented examples and figures to conceptualize the techniques and approaches used. It also contains questions and exercises to reinforce the concepts students have learned.

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CHAPTER - III

CHAPTER - III

METHODOLOGY

3.1 THERMODYNAMICS

Thermodynamics is the relationship between heat, work, temperature, and energy. It deals with the transfer of energy from one place to another and from one form to another. The main concept is that heat is a form of energy corresponding to a definite amount of mechanical work. The laws of thermodynamics describe how the energy in a system change and whether the system can perform useful work on its surroundings.

LAWS OF THERMODYNAMICS ARE:

Zeroth law

If two systems are in thermal equilibrium with a third system, then they are in thermal equilibrium with one another.

First law

Energy cannot be created or destroyed, but it can be converted from one form to another.

* Second law

Energy is transferred or transformed, more and more of it is wasted

Third law

The entropy of a system approaches a constant value as the temperature approaches absolute zero.

We use first and second law.

FIRST LAW OF THERMODYNAMICS AND ITS APPLICATION:

Any thermodynamic system in equilibrium state possesses a state variable called the internal energy(E). Between any two equilibrium states, the change in internal energy is equal to the difference of the heat transfer into the system and work done by the system.

$\Delta U=Q-W$

An electric light bulb transforms electric energy into light energy is an important application.

SECOND LAW OF THERMODYNAMICS AND ITS APPLICATION:

The second law of thermodynamics introduces a property called entropy S, which is an extensive property of a system. The entropy change of a closed system is equal to the heat added reversible to it divided by the absolute temperature of the system. Heating and cooling systems in our homes is an important application.

FIRST LAW OF THERMODYNAMICS:

The first law of thermodynamics states that the change in internal energy of a system equals the net heat transfer into the system minus the net work done by the system. In equation form, the first law of thermodynamics is

$$\Delta U = Q - W (\mathbf{J})$$

Where,

 $\Delta U = Change in internal energy (J)$

Q = Net heat transfer (kJ)

W = Work done by the system (J)

Change in internal energy (ΔU)

The change in internal energy of a system is the sum of the heat transferred and the work done. The heat flow is equal to the change in the internal energy of the system plus the PV work done.

Net heat transfer (Q):

The net heat transfer is the heat transfer into the system minus the heat transfer out of the system. Similarly, the total work is the work done by the system minus the work done on the system.

Work done by the system (W):

The thermodynamics work is the quantity of energy transferred from one system to another. It is a generalization of the concept of mechanics. In the SI

system of measurement, work is measured in joules (symbol: J) the rate at which work is performed is power.

SECOND LAW OF THERMODYNAMICS:

The second law states that there exists a useful state variable called entropy S. The change in entropy delta S is equal to the heat transfer delta Q divided by the temperature T.

$$\Delta S = \frac{\Delta Q}{T} \left(\mathbf{J} / \mathbf{K} \right)$$

Where,

 ΔS = Change in entropy (J/K)

 ΔQ = Differential increment of heat added

T = Temperature in kelvin

Change in entropy(ΔS):

The entropy change of a system in a process is equal to the amount of heat transferred to it in a reversible manner divided by the temperature at which the transfer takes place. The unit of entropy is J/K.

Heat added (ΔQ) :

The heat added to or removed from a substance to produce a change in its temperature is called sensible heat. The units of heat are often defined in terms of the changes in temperature it produces. Another type of heat is called latent heat.

Temperature (T):

The temperature T on the other hand, is a number that's proportional to the total internal energy of the gas. So, Q is the energy a gas gains through thermal conduction, but T is proportional to the total amount of energy a gas has at a given moment.

Uses:

- It ensures higher conversion rates and better efficiencies than thermal and mechanical processes. That is because there is no intermediate step of direct combustion.
- One great advantage of conservation laws such as the first law of thermodynamics is that they accurately describe the beginning and ending points of complex processes, such as metabolism and photosynthesis.
- The second law of thermodynamics allows us to know how well an energy system performs in terms of the quality of the energy.

3.2 C++ (OBJECTED-ORIENTED PROGRAMMING):

C++ is a cross-platform language that can be used to create highperformance applications. C++ is an extension to the C language. C++ gives programmers a high level of control over system resources and memory.

Evolution of C++

C++ is a statically typed, free-form, multi-paradigm, compiled ,general purpose programming language. It is regarded as a middle-level language, as it comprises a combination of both high-level and low-level language features. It was developed by Bjarne Stroustrup starting in 1979 at Bell Labs as an enhancement to the C programming language and originally named "C with Classes". It was renamed to C++ in 1983 according to some writing dissertation made.

C++ is widely used in the software industry, and remains one of the most popular languages ever created. Some of its application domains include systems software, application software, device drivers, embedded software, high-performance server and client applications, and entertainment software such as video games. Several groups provide both free and proprietary C++ compiler software, the GNU Project, Microsoft, Intel, Borland and others. C++ is also used for hardware design, where design is initially described in C++, then analysed, architecturally constrained, and scheduled to create a register transfer level hardware description language via high-level synthesis.

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The language began as enhancements to C, first adding classes, then virtual functions, operator overloading, multiple inheritance, templates, and exception handling among other features. After years of development, the C++ programming language standard was ratified in 1998. The language was updated 4 major times in 2011, 2014, 2017, and 2020 to C++11, C++14, C++17, C++20.

Features of C++

- * Simple
- Abstract Data types
- Machine Independent or Portable
- Mid-level programming language
- Structured programming language
- Rich Library
- Memory Management
- Quicker Compilation
- * Pointers
- * Recursion
- * Extensible
- Object-Oriented
- Compiler based
- * Reusability
- National Standards
- Errors are easily detected
- Power and Flexibility
- Strongly typed language
- Redefine Existing Operators
- Modelling Real-World Problems
- * Clarity

Simple, Abstract & Portable:

C++ is a simple language because it provides a structured approach (to break the problem into parts), a rich set of library functions, data types, etc. In C++, complex data types called Abstract Data Types (ADT) can be created using classes. C++ is a portable language and programs made in it can be run on different machines.

Mid-level / Intermediate & structured programming language

C++ includes both low-level programming and high-level language so it is known as a mid-level and intermediate programming language. It is used to develop system applications such as kernel, driver, etc. C++ is a structured programming language. In this we can divide the program into several parts using functions.

Rich Library & Memory Management:

C++ provides a lot of inbuilt functions that make the development fast. Following are the libraries used in C++ programming are: <iostream>

<cmath>

<cstdlib>

<fstream>

C++ provides very efficient management techniques. The various memory management operators help save the memory and improve the program's efficiency. These operators allocate and deallocate memory at run time. Some common memory management operators available C++ are new, delete etc.

Quicker Compilation, Pointer & Recursion:

C++ programs tend to be compact and run quickly. Hence the compilation and execution time of the C++ language is fast. C++ provides the feature of pointers. We can use pointers for memory, structures, functions, array, etc. We can directly interact with the memory by using the pointers. In C++, we can call the function within the function. It provides code reusability for every function.

Extensible, Object - oriented & Compiler based:

C++ programs can easily be extended as it is very easy to add new features into the existing program. In C++, object-oriented concepts like data hiding, encapsulation, and data abstraction can easily be implemented using keyword class, private, public, and protected access specifiers. Object-oriented makes development and maintenance easier. C++ is a compiler-based programming language, which means no C++ program can be executed without compilation. C++ compiler is easily available, and it requires very little space for storage. First, we need to compile our program using a compiler, and then we can execute our program.

Reusability, National Standards & Errors detection:

With the use of inheritance of functions programs written in C++ can be reused in any other program of C++. You can save program parts into library files and invoke them in your next programming projects simply by including the library files. New programs can be developed in lesser time as the existing code can be reused. It is also possible to define several functions with same name that perform different task. For Example: abs () is used to calculate the absolute value of integer, float and long integer. C++ has national standards such as ANSI. It is easier to maintain a C++ programs as errors can be easily located and rectified. It also provides a feature called exception handling to support error handling in your program.

Power and Flexibility & Strongly typed language:

C++ is a powerful and flexible language because of most of the powerful flexible and modern UNIX operating system is written in C++. Many compilers and interpreters for other languages such as FORTRAN, PERL, Python, PASCAL, BASIC, LISP, etc., have been written in C++. C++ programs have been used for solving physics and engineering problems and even for animated special effects for movies. The list of arguments of every function call is typed checked during compilation. If there is a type mismatch between actual and formal arguments, implicit conversion is applied if possible. A compile-time occurs if an implicit conversion is not possible or if the number of arguments is incorrect.

Redefine Existing Operators:

C++ allows the programmer to redefine the meaning of existing operators such as +, -. For Example, the "+" operator can be used for adding two numbers and concatenating two strings.

Modelling real-world problems & Clarity:

The programs written in C++ are well suited for real-world modelling problems as close as possible to the user perspective. The keywords and library functions used in C++ resemble common English words.

Applications of C++

- Operating Systems
- GUI Based applications
- Web Browers

- Banking Applications
- Compilers
- Databased management software

Uses:

- * Portability
- * Multiparadigm
- Low-level Manipulation
- * Memory Management
- Large Community Support
- * Compatibility with C
- * Scalability

FLOWCHARTS:

A flowchart is a type of diagram that represents an algorithm, workflow or process. The flowchart shows the steps as boxes of various kinds, and their order by connecting the boxes with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analysing, designing, documenting or managing a process or program in various fields.

Simple Flowcharting Symbols:

Terminal:

The rounded rectangles, or terminal points, indicate the flowchart's starting and ending points.



Flow Lines:

The default flow is left to right and top to bottom (the same way you read English). To save time arrowheads are often only drawn when the flow lines go contrary the normal.

Input/Output:

The parallelograms designate input or output operations.



Process:

The rectangle depicts a process such as a mathematical computation, or a variable assignment.



Decision:

The diamond is used to represent the true/false statement being tested in a decision symbol.



Connectors:

Sometimes a flowchart is broken into two or more smaller flowcharts. This is usually done when a flowchart does not fit on a single page, or must be divided into sections. A connector symbol, which is a small circle with a letter or number inside it, allows you to connect two flowcharts on the same page. A connector symbol that looks like a pocket on a shirt, allows you to connect to a flowchart on a different page.



On-Page Connector

Off-Page Connector

Key Terms

Decision Symbol:

A diamond used in flowcharting for asking a question and making a decision.

• Flow Lines:

Lines (sometimes with arrows) that connect the various flowcharting symbols.

Flowcharting:

A programming design tool that uses graphical elements to visually depict the flow of logic within a function.

• Input/ Output Symbol:

A parallelogram used in flowcharting for input/output interactions.

Process Symbol:

A rectangle used in flowcharting for normal processes such as assignment.

3.3 MICROPROCESSOR 8085

Computer's Central Processing Unit (CPU) built on a single Integrated Circuit (IC) is called a **microprocessor**. It is a computer processor where the data processing logic and control is included on a single integrated circuit or a small number of integrated circuits.



Figure 3.3.1. 8085 Microprocessor kit

It is a programmable, multipurpose, clock-driven, register based electronic device that reads binary instructions from a storage device called memory, accepts binary data as input and processes data according to those instructions and provides results as output. The microprocessor contains millions of tiny components like transistors, registers, and diodes that work together.



Figure 3.3.2. 8085 Microprocessor chip

A microprocessor is designed to perform arithmetic and logic operations that make use of small number holding areas called registers. Generally, microprocessor operations include addition, subtraction, comparison of two numbers and fetching numbers from one area to another. The microprocessor follows a sequence to execute the instruction:

* Fetch

- * Decode
- Execute

Initially, the instructions are stored in the storage memory of the computer in sequential order. The microprocessor fetches those instructions from the stored area (memory), then decodes it and executes those instructions till STOP instruction is met. Then, it sends the result in binary form to the output port. Between these processes, the register stores the temporary data and ALU (Arithmetic and Logic Unit) performs the computing functions. The evolution, features and working of an 8085 Microprocessor is described briefly.

Evolution

A Microprocessor is a complete computation engine that is fabricated on a single chip. The first microprocessor was the INTEL 4004, introduced in 1971. The 4004 is a 4-bit processor. The microprocessor constructed to make it into a home computer was the INTEL 8080, a complete 8-bit computer on one chip, introduce in 1974. In 1976, Intel updated the 8080 design with the 8085 by adding two instructions to enable / disable three added interrupt pins and the serial I/O pins. In 1978 Intel introduced the 8086, a 16-bit processor which gave rise to the X86 architecture. It did not contain floating point instructions. In 1980 the Intel released the 8087. It is the first math co-processor. The first microprocessor to make a real splash in the market was the Intel 8088, introduced in 1979 and incorporated into IBM Personal Computer. The Personal Computer market moved from the 8088 to the 80286 to the

80386 to the Pentium H to the Pentium HI to the Pentium IV. All of these microprocessors are made by Intel and all of them are improvement on the basic design of the 8088.Some second source manufactures also produced CMOS version

of the microprocessor 8085-80C85. The 8085 was produced at speeds ranging from 3MHz to 6MHz.



Figure 3.3.3. Intel 4004

INTEL MICROPROCESSOR					
Name	Year	Transistors	Clock Speed	Data Width	
8080	1974	6,000	2 MHz	8 bits	
8085	1976	6,500	5 MHz	8 bits	
8086	1978	29,000	5 MHz	16 bits	
8088	1979	29,000	5 MHz	8 bits	
80286	1982	134,000	6 MHz	16 bits	
80386	1985	275,000	16 MHz	32 bits	
80486	1989	1,200,000	25 MHz	32 bits	
Pentium	1993	3,100,000	60 MHz	32/64 bits	
Pentium II	1997	7,500,000	233 MHz	64 bits	
Pentium III	1999	9,500,000	450 MHz	64 bits	
Pentium IV	2000	42,000,000	1.5 GHz	64 bits	
Pentium IV "Prescott"	2004	125,000,000	3.6 GHz	64 bits	
Intel Core 2	2006	291 million	3 GHz	64 bits	
Pentium Dual Core	2007	167 million	2.93 GHz	64 bits	
Intel 64 Nchalem	2009	781 million	3.33 GHz	64 bits	

Table 3.3.1. Evolution over the years

Pin Diagram:





Figure 3.3.4. (b) Functional pin diagram

Classification of Signals:

All signals can be classified into six groups.

- 1. Address bus
- 2. Data bus
- 3. Control & Status signals
- 4. Power supply & Frequency signals
- 5. Externally initiated signals
- 6. Serial I/O Ports.

Address Bus: A₈ - A₁₅:

These pins carry the higher order of address bus. The address is sent from microprocessor to memory $A_8 - A_{15}$. It carries the least significant 8-bit of memory 1/O address. It is a group of conducting wires which carries address only. Length of Address Bus of 8085 microprocessor is 16 Bit (That is, Four Hexadecimal Digits), ranging from 0000 H to FFFF H, (H denotes Hexadecimal). The microprocessor s085 can transfer maximum 16-bit address which means it can address 65, 536 different memory location. The Length of the address bus determines the amount of memory a system can address. Such as a system with a 32-bit address bus can address 2^32 memory locations. If each memory location holds one byte, the addressable memory space is 4 GB. However, the actual amount of memory that can be accessed is usually much less than this theoretical limit due to chipset and motherboard limitations.

Data Bus: $AD_0 - AD_7$:

Data bus is of 8-bit. It is used to transfer data between microprocessor and memory $AD_0 - AD_7$. It carries the least significant 8-bit address and data bus. It is a group of conducting wires which carries Data only. Data bus is bidirectional because data flow in both directions, from microprocessor to memory or Input/Output devices and from memory or Input/Output devices to microprocessor.

Length of Data Bus of 8085 microprocessor is 8 Bit (That is, two Hexadecimal Digits), ranging from 00 H to FF H. (H denotes Hexadecimal). When it is a written operation, the processor will put the data (to be written) on the data bus, when it is read operation, the memory controller will get the data from specific memory block and put it into the data bus. The width of the data bus is directly related to the largest number that the bus can carry, such as an 8-bit bus can represent 2 to the power of 8 unique values, this equates to the number 0 to 255.A 16- bit bus can carry 0 to 65535.

Control signal:

RD: This signal indicates that the selected IO or memory device is to be read and is ready for accepting data available on the data bus.

WR: This signal indicates that the data on the data bus is to be written into a selected memory.

Status signal:

 $10/\overline{M}$: This signal is used to differentiate IO and Memory operations. S₁ and S₂: These signals are used to identify the type of current operation.

Power Supply:

V_{cc}: It indicates +5v power supply. V_{ss}: It indicates ground signal

Interrupt signals:

TRAP: It is usually used for power failure and emergency shutoff.
RST 7.5: It is a maskable interrupt. It has the second highest priority.
RST 6.5: It is maskable interrupt. It has the third highest priority.
RST 5.5: It is a maskable interrupt. It has the fourth highest priority.
INTR: It is a general-purpose interrupt. It is a maskable interrupt. It has the lowest priority.

Externally Initiated Signals:

INTA: It is an interrupt acknowledgement signal.

RESETIN: This signal is used to reset the microprocessor by setting the program counter to zero.

RESET OUT: This signal is used to reset all the connected devices, when the microprocessor is reset

READY: This signal indicates that the device is ready to send or receive data.

HOLD: This signal indicates that another master is requesting the use of the address and data buses.

HLDA: It indicates that CPU has received the HOLD request and it will relinquish the bus in next clock.

Serial I/O signals:

SOD: The output SOD is set or reset as specified by the SIM instruction.

SID (Serial Input Dataline): The data on this line is loaded into accumulator whenever a RIM instruction is executed.

Clock Signals:

8085 operates on a clock frequency of 3MHz–6MHz depending upon the version selected. Clock is provided by a crystal oscillator of 2 times the frequency, so as to produce a 50% duty cycle clock. The minimum operating frequency of 8085 is 500kHz.

The CLK (out) signal obtained from pin 37 of 8085 is used for synchronizing external devices.

 X_1, X_2 : A crystal (RC, LC, N/W) is connected at these two pins and is used to set frequency of the internal clock generator. This frequency is internally divided by 2.

CLK OUT: This signal is used as the system clock for devices connected with the Microprocessor.

Operating procedures

Generally, a microprocessor performs four different operations: memory read, memory write, input/output read and input/output write. In the memory read operation, data will be read from memory and in the memory write operation, data will be written in the memory. Data input from input devices are I/O read and data input to output device are I/O write operations. The memory read/write and Input/output read and write operations are performed as part of communication between the microprocessor and memory or Input/output device.

Microprocessors communicate with the memory, and I/O device through address bus, data bus and control bus. For the communication, firstly the microprocessor identifies the peripheral device by proper addressing. Then a sends data provides control signal for synchronization. Initially, the microprocessor places a 16-bit address and the address bus. Then the external decoder logic circuit decodes the 16-bit address on the address bus and the memory location is identified. Thereafter, the microprocessor sends MEMR control signal which enable the memory IC. After that, the content of the memory location is placed on data bus and also sent to the microprocessor.

The step-by-step procedure of data flow is given below:

The 16-bit memory address is stored in the program counter. Therefore, the program counter sends the 16-bit address on the address bus. The memory address decodes and identifies the specified memory location.

- The control unit sends the control signal RD in the next clock cycle and the memory
 IC is enabled RD is active for two clock periods.
- When the memory IC is enabled, the byte from the memory location is placed on the data bus AD₀ AD₂ after that data is transferred is the microprocessor.

Bus organization of 8085 microprocessor

Bus is a group of conducting wires which carries information, all the peripherals are connected to microprocessor through Bus.



Figure 3.3.5. Bus organization of 8085 Microprocessor

Uses:

3

- The microprocessor is that these are general purpose electronics processing devices which can be programmed to execute a number of tasks.
- * Compact size.
- * High speed.
- Low power consumption.
- It is portable.

- It is very reliable.
- * Less heat generation.
- . The microprocessor is very versatile.
- The microprocessor is its speed, which is measured in basically Hertz. For instance, a microprocessor with a measured speed 3 GHz, shortly GHz is capable of performing 3 billion tasks per second.
- The microprocessor is that it can quickly move data between the various memory locations.

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CHAPTER - IV

- a series encoded for to at 190%. then determine the availability of heat stanger.
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- C. of the approximation as at 05000, then depermine the availability of montenently.

4.2 Minimal celembridan

- To First the Fieral administration of the gas for the given three values of work.
 - A. W 7505.
 - C. W = 65001

Solution:

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CHAPTER - IV

PROBLEM AND EXECUTION

4.1 Statement Problem

4.1.1 First law of Thermodynamics

5000J of heat are added to two moles of an ideal monoatomic gas, initially at a temperature of 500k.

- A. While the gas performs 7500J of work done. What is the final temperature of the gas?
- B. While the gas performs 8500J of work done. What is the final temperature of the gas?
- C. While the gas performs 6500J of work done. What is the final temperature of the gas?

4.1.2 Second Law of Thermodynamics

A reversible heat Engine receives 4000KJ of heat from a constant temperature source at 600K.

- A. If the surrounding is at 100K then determine the availability of heat energy.
- B. If the surrounding is at 200K then determine the availability of heat energy.
- C. If the surrounding is at 250K then determine the availability of heat energy.

4.2 Manual calculation

 To Find the Final temperature of the gas for the given three values of work done(W)

A. W = 7500J,
B. W = 8500J,
C. W = 6500J

Solution:

A. Q = 5000J; W = 7500J; $\Delta U = \Delta Q - \Delta W$ n = 2 moles;

R = 8.31 J/Moles.
$\Delta U = 5000 - 7500$ $\Delta U = -2500 \mathrm{J}$ $\Delta \mathbf{U} = \left(\frac{3}{2}\right) \mathbf{n} \mathbf{R} \Delta \mathbf{T}$ $-2500 = \left(\frac{3}{2}\right)(2) (8.31) \Delta T$ $-2500 = 24.93\Delta T$ $\Delta T = -\frac{2500}{24.93}$ $\Delta T = -100K$ $T_f = 500 - 100$ $T_f = 400K$ A. Q = 5000J; W = 8500J; n = 2 moles; R = 8.31J/Moles. $\Delta \mathbf{U} = \Delta \mathbf{Q} - \Delta \mathbf{W}$ $\Delta U = 5000 - 8500$ $\Delta U = -3500 K$ $\Delta \mathbf{U} = \left(\frac{3}{2}\right) \mathbf{n} \mathbf{R} \Delta \mathbf{T}$

 $-3500 = \left(\frac{3}{2}\right)(2)(8.314)\Delta T$ -3500 = 24.93∆T $\Delta T = -\frac{3500}{24.93}$ $\Delta T = -140 K$ $T_f = 500 - 140$ $T_{f} = 360K$

A. Q = 5000J; W = 6500J;

n = 2 moles; R = 8.31 J/Moles.

 $\Delta \mathbf{U} = \Delta \mathbf{Q} - \Delta \mathbf{W}$ $\Delta U = 5000 - 6500$ $\Delta U = -1500 K$ $\Delta \mathbf{U} = \left(\frac{3}{2}\right) \mathbf{n} \mathbf{R} \Delta \mathbf{T}$ $-1500 = \left(\frac{3}{2}\right)(2)(8.31)\Delta T$ $-1500 = 24.93\Delta T$ $\Delta T = -\frac{1500}{24.93}$ $\Delta T = -60.7395 K$ $\Delta T = -60K$ $T_f = 500 - 60$ $T_{f} = 440K$

- 2. To find the availability of heat for the given three values of surrounding temperature (To)
 - $A.T_0 = 100K$ **B.** $T_0 = 200 K$ **C.** $T_0 = 250 K$

Solution:

A. Q = 6000KJ;

 $T_1 = 600K;$

 $T_0 = 100K.$

$$\Delta S = \frac{Q_1}{T_1 + T_2}$$

$$\Delta S = \frac{4000}{600 + 100}$$

$$\Delta S = \frac{4000}{700}$$
$$\Delta S = 5.7142$$
$$\Delta S = 5.71 \text{KJ/K}$$

Availability

$$A = Q_1 - T_0 (\Delta S)$$

$$\dot{A} = 4000 - 100 (5.71)$$

$$A = 4000 - 571$$

$$\mathbf{A} = \mathbf{3429KJ}$$

$$B = 6000 \text{KJ};$$

$$\Delta S = \frac{Q_1}{T_1 + T_2}$$
$$\Delta S = \frac{4000}{600 + 200}$$
$$\Delta S = \frac{4000}{800}$$

 $T_1 = 600K;$

$$\Delta S = 5 \text{ KJ/K}$$

Availability

$$A = Q_1 - T_0 (\Delta S)$$

$$A = 4000 - 200 (5)$$

$$A = 3000 \text{ KJ}$$

C. Q = 6000 KJ;

$$T_1 = 600K$$

$$T_0 = 250 K$$

 $T_0 = 200K.$

$$\Delta S = \frac{Q_1}{T_1 + T_2}$$
$$\Delta S = \frac{4000}{600 + 250}$$
$$\Delta S = \frac{4000}{850}$$
30

$$\Delta S = 4.705$$

 $\Delta S = 4.7 \text{ KJ/K}$
Initiality
 $A = Q_1 - T_8 (\Delta S)$
 $A = 4000 - 250(4.7)$
 $A = 2825 \text{ KJ}$

4.3. Tabulation and Graph

AVH

FIRST LAW OF THERMODYNAMICS:

Number	of moles	Initial Temperature (K)	Work done (J)	Final Temperature (K)
٨	2	500	7500	400
B	2	500	8500	360
с	2	500	6500	440

Table 4.3.1. Final temperature of the first law of the thermodynamics



Graph 4.3.1. Variation of final temperature with varied work done

SECOND LAW:

Reversible Heat		Constant Temperature (K)	Surrounding Temperature (K)	Availability of heat (KJ)	
A	4000	600	100	3429	
B	4000	600	200	3000	
c	4000	600	250	2825	

Table 4.3.2. Availability of heat of the second law of thermodynamics



Graph 4.3.2. Variation of Availability of heat with varied surrounding temperature

4.4.1. Flowchart for solving the problem in first law of thermodynamics



4.4.2. Flowchart for solving the problem in second law of thermodynamics



4.5 C++Program

4.5.1 Program to find final temperature using first law of thermodynamics

#include<iostream.h> // header file standard input or output
#include<conio.h> // header file
#include<math.h>> //mathematical function
#include<stdio.h> // input output functions
void main () //main function will not return any value

int U,Q,W,n,T,K,ft; // numerical value holding whole numbers float m; //numerical values holding decimal numbers clrscr();

cout<<"Initial Temperature: \n";</td>// displays outputcout<<"Enter the value of Q : ";</td>// displays outputcin>>Q;// accepts inputcout<<"Enter the value of W: ";</td>// displays output

cin>>W; // accepts input

U = Q - W;

}

cout<<"U:"<<"="<<"J\n"; // displays output

cout << "Enter the value of n : \n";// displays output

cin>>n; // accepts input

m = ((1.5)*n*8.31);

cout<<"Value: "<<m<<"\n";

T = U/m;

// displays output

cout<<"temp\n"<<T<<"\n";</td>// displays outputcout<<"To calculate final temp : \n";</td>// displays outputcout<<"Enter the value of K : \n";</td>// displays outputcin>>K;// accepts input

ft = K+T; cout<<"FINAL TEMPERATURE: \t"<<ft; // displays output getch(); //get character

Output A: Initial Temperature: Enter the value of Q : 5000 Enter the value of W : 7500 U = -2500J Enter the value of n : 2 Value : 24.93 Temperature: -100 To calculate final temperature: Enter the value of K: 500 FINAL TEMPERATURE : 400

Output B:

Initial Temperature: Enter the value of Q : 5000 Enter the value of W : 8500 U = -3500J Enter the value of n : 2 Value : 24.93 Temperature : -140 To calculate final temperature: Enter the value of K : 500 FINAL TEMPERATURE : 360

Output C: Initial Temperature: Enter the value of Q : 5000 Enter the value of W : 6500 U = -1500J

Enter the value of n: 2 Value : 24.93 Temperature : -60 To calculate final temperature: Enter the value of K: 500 FINAL TEMPERATURE : 440

4.5.2. Program to calculate the change in entropy using second law of thermodynamics

#include<iostream.h> // header file standard input or output
#include<conio.h> //header file
#include<stdio.h> // input output functions
#include<math.h> //mathematical function
void main() //main function will not return any value
{

```
float q,t1,t2,s,ah; //numerical values holding decimal number
cout<<"Enter the total heat received(Q):"; // displays output
cin>>q; // accepts input
cout<<"\n Enter the temperature from source(T1):"; // displays output
cin>>t1; // accepts input
```

```
cout<<"\n Enter the surrounding temperature(T2):"; // displays output
```

```
cin>>t2; // accepts input
```

s=q/(t1+t2);

ah=q-t2*s;

cout<<"\n-----";

cout<<"\n The change in entropy"<<s<"KJ/K"; // displays output cout<<"\n\n The availability of heat (AH):"<<ah<<"KJ"; // displays output cout<<"\n-----";</pre>

getch(); //get character

```
}
```

Output A:

Enter the total heat received(Q):4000 Enter the temperature from source(T1):600 Enter the surrounding temperature(T2):100

The change in entropy :5.714286KJ/K The availability of heat (AH): 3428.571533KJ

Output B:

Enter the total heat received(Q):4000 Enter the temperature from source(T1):600 Enter the surrounding temperature(T2):200

The change in entropy:5KJ/K

The availability of heat (AH):3000KJ

Output C:

Enter the total heat received(Q):4000 Enter the temperature from source(T1):600 Enter the surrounding temperature(T2):250

The change in entropy:4.705883KJ/K The availability of heat (AH): 2823.529297KJ

4.6. Microprocessor 8085 program 4.6.1 program to find final temperature using first law of thermodynamics

XGHG LHLD 2402H MOV A, E SUB L **JNC LOOP 1** INR C

LOOP 1:

STA 2408H MOV A, D SUB C SUB H STA 2409H LHLD 2408H LDA 2407H MOV C, A LXI D1 0000H MOV A, L SUB C MOV L, A JNC LOOP 3 DCR H INX D MOV A, H CPI 00H JNZ LOOP 2 MOV A, L

CMP C

LOOP 2:

LOOP 3:

JNC LOOP 2	
SHLD 240CH	
XCHG	
SHLD 240AH	
LHLD 2404H	
XCHG	
LHLD 240BH	
MOV A, E	
SUB L	
JNC LOOP 4	
INR C	

LOOP 4: STA 2500H MOV A, D SUB H STA 2501H HLT

Output

nory Address	Input	Values
2400	4C	7500
2401	1D	(1D4CH)
2400	34	8500
2401	21	(2134H)
2400	64	6500
2401	19	(1964H)
	hory Address 2400 2401 2400 2401 2400 2401 2401 2401 2400 2401 2400 2401	Input 2400 4C 2401 1D 2400 34 2401 21 2400 64 2401 19

Table 4.6.1. (a) Input for First law of Thermodynamics

Memory Address	Output	Values
2500	90	100
2501	01	(0190H)
2500	68	360
2501	01	(0168H)
2500	B8	440
2501	01	(01B8H)

Table 4.6.1. (b) Output for First law of Thermodynamics



Fig 4.6.1. (a) LSB of output A for First law of Thermodynamics



Fig 4.6.1. (b) MSB of output A for First law of Thermodynamics

4.6.2. Program to calculate the availability of heat using second law of

thermodynamics

LXI SP, 2400H LXI H, Input LXI D 0258H SHLD 2300H DAD D PUSH H SHLD 2302H XCHG LXI H, 0FA0H SHLD 2304H CALL D1 PUSH B 42 XCHG POP H SHLD 2306H LXI B, 0064H CALL L1 POP D PUSH D PUSH H CALL D1 PUSH B POP H SHLD 2308H LHLD 2306H PUSH H POP B LHLD 2300H XCHG CALL L1 SHLD 2350H LHLD 2308H PUSH H POP B CALL L1 LXI D, 0064H CALL D1

LHLD 2350H

DADB

XCHG

LHLD 2304H

CALL S1

SHLD 2360H

RST 0

LOOP 2:

LOOP 1:

LOOP:

L1: LXI H, 0000H DAD D DCX B MOV A, C ORA B JNZ LOOP2 RET D1: LXI B CALL S1 JNC LOOP JMP H1 INX B JMP LOOP1 H1: DAD D RET S1: MOV A, L SUB E 44

MOV L, A MOV A, H SBB D MOV H, A

Output:

N	Iemory Address	Input	Values
	2103	64	100
A	2104	00	(0064H)
	2103	C8	200
В	2104	00	(00C8H)
	2103	FA	250
C	2104	00	(00FAH)

Table 4.6.2. (a) Input for second law of Thermodynamics

nory Address	Output	Values
2360	65	3429
2361	0D	(0D65H)
2360	B8	3000
2361	0B	(0BB8H)
2360	09	2825
2361	0B	(0B09H)
	nory Address 2360 2361 2360 2361 2360 2361 2360 2361	nory AddressOutput23606523610D2360B823610B23600923610B

Table 4.6.2. (b) Output for second law of Thermodynamics



Fig 4.6.2. (a) LSB of output A for second law of Thermodynamics



Fig 4.6.2. (b) MSB of output A for second law of Thermodynamics

4.7. Validation of first and second law of thermodynamics

First law of thermodynamics:

Manual calculation		T	
Manual calculation	C++	Microprocessor	
400	400	0190H (400)	
360	360	0168H (360)	
440 .	440	01B8H (440)	

Table 4.7.1. Comparing manual calculation with C++ and Microprocessor of first law of thermodynamics

Second law of thermodynamics

Manual calculation	C++	Microprocessor
3429	3428.5	0D65H (3429)
3000	3000	0BB8H (3000)
2825	2823.5	0B09H (2825)

Table 4.7.2. Comparing manual calculation with C++ and Microprocessor of second law of thermodynamics

AL & Discussion

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2 Conclusion

CHAPTER - V

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- · With the help of Cive and Müssleprocessor programs, margin and and an and
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CHAPTER - V

CONCLUSION

5.1. Result & Discussion

 C^{++} program for solving the first and second law of thermodynamics problems are executed and the outputs are obtained. *

In same way, the microprocessor 8085 program for solving thermodynamic *

- equation are executed and the outputs are obtained in hexadecimal format. Graphs are plotted to show the variation of final temperature for work done in the
- ideal monoatomic gas and availability of heat energy of the surrounding. ÷
- In first law, moles and initial temperatures are kept constant while the work done varies.
- In second law reversible heat is kept constant while the surrounding temperature varies.

5.2 Conclusion

- Large mathematical and physical equations can be solved by using C++ and microprocessor just like the thermodynamic problems that we solved. It has also provided us outputs to draw a certain result.
- In conclusion, C++ and Microprocessor programs are the basis of the most advanced Engineering and Artificial Intelligence (AI) in many fields.
- With the help of C++ and Microprocessor programs, complex mechanisms are made easier.
- Hence computations pave way to the Modern world.

5.3 Future Scope

- Not only in thermodynamics, but also the problems in Newton's law, relativistic theory, Lorentz transformation etc.., can be solved.
- Large problems can be solved easily by using microprocessor.
- In high speed it can execute millions of instructions, even complex derivations can be solved.



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ANNEXURE

//Program to find final temperature using first law of thermodynamics #include<conio.h> #include<math.h> #include<stdio.h> void main() 1 int U,Q,W,n,T,K,ft; float m; clrscr(); cout << "Initial Temperature:\n"; cout << "Enter the value of Q:"; cin>>Q; cout << "Enter the value of W:"; cin>>W; U=Q-W;cout<<"U:"<<"="<<"J\n"; cout << "Enter the value of n:\n"; cin>>n; m = ((1.5)*n*8.31);cout << "Value:" << m << "\n"; T=U/m: cout<<"temp\n"<<T<<"\n"; cout << "To calculate final temp :\n"; cout << "Enter the value of K:\n"; cin>>K; ft=K+T; cout << "FINAL TEMPERATURE:\t" << ft; getch(); }

Output A:

Initial Temperature: Enter the value of Q:5000 Enter the value of W:7500 U = -2500J Enter the value of n: 2 Value:24.93 Temperature:-100 To calculate final temperature : Enter the value of K:500 FINAL TEMPERATURE: 400

Output B:

Initial Temperature: Enter the value of Q:5000 Enter the value of W:8500 U = -3500J Enter the value of n: 2 Value:24.93 Temperature:-140 To calculate final temperature: Enter the value of K:500 FINAL TEMPERATURE:360

Output C:

Initial Temperature: Enter the value of Q:5000 Enter the value of W:6500 U = -1500J Enter the value of n: 2 Value:24.93 Temperature:-60 To calculate final temperature: Enter the value of K:500 FINAL TEMPERATURE :440 //Program to calculate the availability of heat using second law of

thermodynamics

```
#include<iostream.h>
#include<conio.h>
#include<stdio.h>
#include<math.h>
void main()
5
float q,t1,t2,s,ah;
cout << "Enter the total heat received(Q):";
cin>>q;
cout << "\nEnter the temperature from source(T1):";
cin>>t1;
cout << "\nEnter the surrounding temperature(T2):";
cin>>t2;
s=q/(t1+t2);
ah=q-t2*s;
cout<<"\n-----
                              cout << "\nThe change in entropy" << s << "KJ/K";
cout << "\n\n The availablity of heat (AH):" << ah << "KJ";
                                         -":
cout<<"\n-----
getch();
```

3

Output A:

Enter the total heat received(Q):4000 Enter the temperature from source(T1):600 Enter the surrounding temperature(T2):100

The change in entropy :5.714286KJ/K The availablity of heat (AH): 3428.571533KJ

Output B:

Enter the total heat received(Q):4000 Enter the temperature from source(T1):600 Enter the surrounding temperature(T2):200

The change in entropy:5KJ/K

The availablity of heat (AH):3000KJ

Output C:

Enter the total heat received(Q):4000

Enter the temperature from source(T1):600

Enter the surrounding temperature(T2):250

The change in entropy:4.705883KJ/K The availablity of heat (AH): 2823.529297KJ

STUDY OF ACOUSTICAL PARAMETERS OF ETHYLPROPIONATE WITH CURCUMIN

Project report submitted to the Department of Physics

ST. MARY'S COLLEGE (AUTONOMOUS),

THOOTHUKUDI

Affiliated to Manonmaniam Sundaranar University, Tirunelveli In partial fulfilment of the requirement for the award of

BACHELOR'S DEGREE IN PHYSICS

By

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D. J. Jasmine	120	19AUPH13
D. Jenifer Carlin	-	19AUPH14
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Department of physics

ST. MARY'S COLLEGE (AUTONOMOUS)

Reaccredited with "A+" Grade by NAAC

Thoothukudi

2021-2022

CERTIFICATE

This is to certify that this project work entitled, "STUDY OF ACOUSTICAL PARAMETERS OF ETHYL PROPIONATE WITH CURCUMIN" is submitted to ST. MARY'S COLLEGE (AUTONOMOUS), THOOTHUKUDI in partial fulfilment for the award of Bachelor's Degree in Physics and is a record of work done during the year 20212022 by the following students.

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EXAMINER

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RINCIPAL

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2021-2022

CERTIFICATE

This is to certify that this project work entitled, "STUDY OF ACOUSTICAL PARAMETERS OF ETHYL PROPIONATE WITH CURCUMIN" is submitted to ST. MARY'S COLLEGE (AUTONOMOUS), THOOTHUKUDI in partial fulfilment for the award of Bachelor's Degree in Physics and is a record of work done during the year 20212022 by the following students.

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CHAPTER-I

INTRODUCTION :-

The Ultrasonic velocity determined by the interferometer method is considered as more reliable and precise as compared to other methods. In many industrial applications, rather than single component liquid system, liquid mixtures are used in processing and product formulations (V.D. Bhandhakkar et al 2014). The significance of volumetric, acoustic and thermodynamic studies in mixtures have been used for understanding the intermolecular interactions for interpreting different types of interactions .This method find extensive applications for characterizing aspects of physicochemical behaviour such as the nature of molecular interactions in pure liquid as well as liquid mixtures (S.Thirumaran et al). Ultrasonic velocity is one of the important parameters frequently used to investigate intermolecular interactions in binary liquid mixtures (Shaik babu et al 2011). Now -a- days ultrasonic is used in area of intense scientific and technological research. Thermo-acoustic parameters are the essential sources of information for better understanding of non-ideal behaviours of complex binary liquid system (J.N. Ramteke et al, 2014). Ultrasonic measurements are very useful in chemical, food processing, pharmaceuticals material testing and underwater ranging and cleaning and they are commonly employed in mechanical machinery of materials, preparation of colloids or emulsions, imaging of biological tissues etc... (Sk. Md Nayeem et al, 2014). Ultrasonic studies in polymeric solutions have drawn the attention of many researches in the recent years. This method is a powerful and effective tool for investigation of polymer solutions and behaviour of polymer chain in an ultrasonic field (S.S. Kulkarani et al, 2012). Ultrasonic propagation parameters provides valuable information regarding the behaviour of binary liquid systems. because intramolecular association, dipolar interactions, complex formation and related structural changes affect the compressibility of the system which in turn produces corresponding variations in the ultrasonic velocity (P. Paul Divakar et al, 2012). The study of intermolecular interactions play an important role in the development of molecular sciences .The development of liquid state theories was quite retarted compared to the theories of gases state and solid state .However ,during the last forty years there has been a considerable importance and a number experimental techniques have been used to investigate the interactions between the components of binary liquid mixtures .It is obvious that the study of excess compressibility and excess molar volume gives important information on intermolecular forces existing in binary liquid mixtures(B. Sathyanarayana et al, 2006). Ultrasonic velocity and density data can be used to investigate the solute- solute interaction using statistical theory solutions. Measurement of physiochemical properties such as density and ultrasonic velocity of pure components and their binary mixtures are being increasingly used as tools for investigation of the pure components and the nature of intermolecular interactions between the components of liquid mixtures (J.N. Ramteke et al, 2014). The liquid state theory should be in a position to explain the thermodynamic behaviour of simple liquids, equilibrium and transport properties of liquids and results of x-rays and neutron diffraction techniques. It has been pointed out by several workers that this ultrasonic technique has been adequately employed to investigate the properties of any
substance to understand the nature of molecular interactions in pure liquids (S. Mullainathan *et al*, 2010).

Taking into account, the varied applications of ultrasonic studies we have designed this project using Ethyl propionate with curcumin to carry out the acoustical study of parameters. Ethyl propionate appears as a clear colorless liquid with a pineapple-like odor. It is a propanoate ester of ethanol. It has a role as a metabolite. It is used in perfumery and fragrance. It is used to manufacture various propionates which used in the reduction of pharmaceuticals, antifungal agents, agrochemicals, plastics, plasticizers, rubber chemicals, dyes, artificial flavors and perfumery synthetics. It is used also as a solvent and in nickel-electroplating solutions (PubChem release 2021).

Curcumin is a natural yellow dye derived from the rhizome of Curcuma Longa Linn. It is responsible for the most of the therapeutic effects of turmeric used widely as a food colouring. It is best known for the Ayurvedic medicine for centuries on the Indian subcontinents a pharamacological safety drug because of it's antioxidant and antiflammatory effects (R. Soundar *et al*, 2021). By considering the utility of above two given solutions that is Ethyl propionate and curcumin, we have chosen these two solutions as the experimental mixture for the acoustical studies.

Objectives:

Taking into account the significant reasons for the study of acoustic parameters, the project was carried out with the following objectives.

- 1. To determine the ultrasonic velocity of the experimental mixtures of different concentrations.
- 2. To determine the density of the experimental mixtures.
- 3. To determine the coefficient of viscosity of the experimental mixtures.
- To calculate the values of derived parameters such as Adiabatic compressibility (β), Free length (L), Relaxation time (ι), Acoustic impedance (Z) and Ultrasonic attenuation (α/f²)

CHAPTER-II

REVIEW OF LITERATURE:

Mr. S. Thirumaran et al (2010) have studied the ultrasonic velocity, density, viscosity. They measured the binary mixtures of 1-propanol with toluene, benzene and cyclohexane at 303K. The sound velocity, viscosity and density were used to calculate the acoustical parameters such as adiabatic compressibility(βa), free length (Lf), free volume (Vf), internal pressure(πi), acoustic impedance(Z) and molar volume (Vm).

Mr. V. D. Bhandhakar et al (2014) have studied the molecular interaction on ultrasonic technique in the binary liquid mixture of Methylmethacrylate in 1, 4-dioxane at 303K and 2MHz frequency. The values of density, ultrasonic velocity(U) and viscosity were measured. The acoustical parameters such as adiabatic compressibility(βa), intermolecular free length (Lf), acoustic impedance (Z), internal pressure (πi) and relaxation time(τ) were evaluated. The result have been discussed with strength of molecular interactions in the binary system.

Mr. Shaik Babu et al (2011) have studied the ultrasonic velocity (U), density, viscosity and measurements have been carried out for the binary mixtures of acetyl acetone with benzene, carbon tetra chloride and isoamyl alcohol at 301K. From the measured values of ultrasonic velocity, density and viscosity, acoustical parameters such as internal pressure (π i), free volume (Vf), adiabatic compressibility (β a), molecular free length(Lf), acoustic impedance (Z), relaxation time (τ) have been calculated. The results have been analyzed and interpreted in terms of molecular interactions.

Mr. J. N. Ramteke et al (2014) have studied the ultrasonic velocity, density, viscosity and measured the binary mixtures of triethylamine with Acetonitrile at 305.15K. The absorption and velocity of sound in binary mixtures of triethylamine with Acetonitrile have been measured at a central frequency of 5MHz, using the interferometer. From the experimental data, adiabatic compressibility (β a), free length (Lf), free volume (Vf), internal pressure (π i) acoustic impedance (Z) and cohesive energy(H) have been calculated. The adiabatic compressibility and excess compressibility were calculated from the velocity and the density measurement. The excess parameters have been used to discuss the presence of significant molecular interactions in binary mixture.

Sk. Md Nayeem et al (2014) have studied the ultrasonic speed (U), density have been measured in binary liquid mixtures of cyclohexanone with isomers of butanol at 308.15K. From the experimental data molar volume (Vm), adiabatic compressibility(βa),

intermolecular free length (Lf), acoustic impedance(Z) have been calculated.

Mr. B. Sathyanarayana et al (2006) have studied the densities and speeds of sound of mixtures of 1,2 dichloroethane, 1,1,2 trichloroethane, 1,1,2,2 tetrachloroethane, trichloroethene and tetrachloroethene with N-methyl acetaminophen at a temperature of 308.15K. The parameters such as isentropic compressibility and intermolecular free length (Lf) have been computed using speed and density values. The results are discussed in the light of intermolecular interactions occurring in the solutions.

Ms. Archana Pandey et al (2011) have studied the ultrasonic velocity, density, refractive indices for systems at 305.15K, 308.15K, 313.15K, 318.15K, 323.15K and 323.15K. From the experimental data adiabatic compressibility(β a), intermolecular free length (Lf), internal pressure(π i), acoustic impedance (Z), molar refraction, polarizability, thermal expansion coefficient, Rao's molar sound function, solvation number, relative association parameter have been computed. The thermal expansion coefficient of the systems from their respective experimental densities and refractive indices are estimated by Lorentz-Lorenz equation and Eykman equations. The refractive index (n), molar refraction, thermal expansion coefficient and polarizability are useful for predicting many physico-chemical properties of solutions.

Mr. S. Mullainathan et al (2010) have studied the ultrasonic velocity, density, viscosity at 303K in the binary systems of 1,4-dioxane and acetone with water. From the experimental data, various acoustical parameters such as adiabatic compressibility (β a), intermolecular free length (Lf), free volume (Vf), internal pressure (π i), Rao's constant (R), Wada's constant (W) and specific acoustical impedance (Z) are calculated. The results are interpreted in terms of molecular interaction between the components of the mixtures.

Mr. R. Soundar (2021) has studied the ultrasonic velocity, density and viscosity for Curcumin with primary alcohols binary mixture viz, 1-propanol at 303K using ultrasonic interferometer. Thermodynamic parameters such as adiabatic compressibility(β a), intermolecular free length (Lf), free volume (Vf), acoustic impedance (Z) and the molecular association have been calculated. The result showed a non linear variations of acoustical parameters which confirmed the presence of molecular associative nature.

P. Paul Divakar et al (2012) have studied the ultrasonic velocity and density measurements in two binary liquid mixtures Isopropyl acetate (IPA) and Isobutyl acetate (IBA) with cyclohexanone as a common component at 303K, at fixed frequency of 2MHz using single crystal variable path interferometer and specific gravity bottle respectively. The experimental data have been used to calculate the acoustic impedance (Z), adiabatic compressibility(βa), intermolecular free length (Lf), and molar volume (Vm). The excess thermodynamic parameters have been evaluated and discussed in the light of molecular interactions.

Ms. Susmita Kamila (2012) has studied the ultrasonic velocity and density measurements for a number of binary liquid mixtures involving different commercial solvent extractants, LIX reagents. The values of velocity have been discussed in terms of percentage variations.

Ms. S. S. Kulkarni et al (2016) have studied the ultrasonic velocity, density and viscosity for the mixture of polyvinylidene fluoride (PVDF) in acetone and dimethylformamide (DMF) of various ratios at 300K using ultrasonic interferometer, pykanometer and Ostwald viscometer. The acoustic parameters adiabatic compressibility(β a), intermolecular free path length (Lf), acoustic impedance (Z), relative association (RA), ultrasonic attenuation, and relaxation time(τ) have been estimated using experimental data. The variation of these acoustic parameters is explained in terms of solute-solvent molecular interaction in a polymer solution.

Mr. G. Nath et al (2009) have studied the densities and ultrasonic velocities of binary mixture of diisopropyl ether (DIPE) and bromobenzene (BB) measured at different frequencies (1 MHz, 3 MHz and 5MHz) over the range of mole fraction of diisopropyl ether (DIPE) at temperature 303K. The intermolecular free length (Lf), isentropic compressibility(β a), acoustic impedance (Z) and excess values of isentropic compressibility have been computed using values of ultrasonic velocity (C) and density.

Mr. Kirandeep Kaur et al (2015) have studied the ultrasonic velocity, density and viscosity of binary mixtures of chloroform and methanol using ultrasonic interferometer, 30ml gravity bottle and Ostwald's viscometer at frequency 2MHz and constant temperature 295K. The thermo acoustical parameters like adiabatic compressibility(β a), acoustic impedance, intermolecular free length (Lf), relaxation time(τ), ultrasonic attenuation, effective molar weight, free volume (Vf), wada's constant, Rao's constant, Vander waal's constant, internal pressure(π i), Gibb's free energy and enthalpy were also computed. The weak interaction between the molecules of the binary mixture was founded.

B. Nagarjun et al (2015) have done the thermodynamic and acoustic study on molecular interactions in certain binary liquid systems involving ethyl benzoate. Speeds of sound and density for binary mixtures of ethyl benzoate N,N-diethyl for a ideal, N,N- Dimethyl acetanide and N,N-diethylamide were measured as a function of mole fraction at temperature 305.15K, 308.15K, 313.15K and 318.15K and atm pressure. From experimental data, adiabatic compressibility(β a), intermolecular free length (Lf) and molar volume (Vm) were computed. The excess values of the above parameters were also evaluated and discussed in light of molecular interactions. Deviation in adiabatic compressibility and excess intermolecular free length are found to be negative over the mole fraction of ethyl benzoate indicating the presence of strong interactions between the molecules. The result obtained as binary data were correlated as a function of mole fraction by using the Redlich-Kister eqn.

Mr. A. Moses Ezhil Raj et al (2009) have made the ultrasonic study on binary mixture containing dimethyl formamide and methanol over the entire miscibility range (0<x<1) between temperatures 303-323K. The experimental density and speed of ultrasound measurements in connection with literature data have been measured for pure N,N-dimethyl formamide (DMF), methanol and their binary mixtures over the whole miscibility range at different temperatures 303,308,313,318 and 323K. These parameters were used to determine the adiabatic compressibility(β a), intermolecular free length (Lf), molar compressibility, molar sound velocity, acoustic impedance (Z) and relaxation strength. The complex formation through intermolecular hydrogen bonding was confirmed from the recorded FTIR spectra. Available thermal energy breaks the bonds between the associated molecules into their respective monomers on increasing the temperature The results were found using the measured and calculated acoustic parameters.

Ms. Srilatha M et al (2015) have made the ultrasonic studies on binary mixtures of Ethyl oleate + Isopropanol at 305.15K to 318.15K temperatures. Density, viscosity and ultrasonic velocities in the temperature range 303K to 318K were determined for various mole fractions of two organic liquids Ethyl Oleate and Isopropanol. Thermo acoustic parameters like adiabatic compressibility(β a), intermolecular free length (Lf), excess molar volume (Vm) and internal pressure(π i), were calculated. The results were interpreted in terms of intermolecular interactions between two organic liquids.

Ms.Rupali Talegaonkar et al (2013) have studied some acoustic properties of substituted Thiazolyl Schiff's bases in binary solvent mixtures at 303K. Density and ultrasonic velocity(U) in binary mixtures of Thiazolyl substituted Schiff's bases with dioxane water, acetone water and ethanol water mixture were measured at 303K using a ultrasonic interferometer at a frequency of 2MHz. Various thermodynamic parameters such as adiabatic compressibility(β a), apparent molar compressibility, apparent molar volume, intermolecular free length (Lf), specific acoustic impedance (Z) and relative association (RA) have been calculated.

The results were used to discuss the interaction between solute and solvent.

Mrs.Ninima Mohanty et al (2015) have studied the Thermodynamical Acoustic parameters of binary mixture of DBP with Toluene at 308K at different frequencies. Ultrasonic investigation of molecular interaction in a binary mixtures of Di-n-butyl phthalate with toluene is carried out at different frequencies at temperature of 308K. They measured experimental values of density and acoustic parameters such as intermolecular free length (Lf), relative association (R), available volume, molar volume (V) etc., The result conveyed that these parameters express the nature and strength of molecular interaction of DBP with toluene.

CHAPTER III

MATERIALS AND METHODS:

The knowledge of thermodynamic and transport properties of liquid mixtures is useful in industrial processes. Ultrasonic and viscometric parameters offer simple, easy and accurate ways for calculating several physical parameters which throw light on molecular interactions in solutions. Many engineering problems require quantitative data of the viscosity and density of the liquid mixtures.

This project deals with the experimental study of ultrasonic velocity, density and viscosity in a liquid mixture at room temperature. It deals with a detailed study of ultrasonic velocity in liquid mixtures of Ethyl propionate with curcumin for different concentration at 301K. The parameters such as ultrasonic velocity (v), density (ρ) and viscosity(η) and computed parameters such as adiabatic compressibility(βa), free length (L_f), acoustical impedance (Z), Relaxation time (ι) and ultrasonic attenuations (α/f^2) are studied.

MATERIAL CHOSEN :

ETHYL PROPIONATE:



USES:

- 1. Ethyl propionate is used in perfumery and fragrance.
- 2. It is used to manufacture various propionates which is used in the reduction of pharmaceuticals, anti-fungal agents, agrochemicals, plastics, plasticizers, rubber chemicals, dyes, artificial flavors and perfumery synthesis.
- 3. It is also used as a solvent and in nickel-electroplating solutions.

CURCUMIN:



USES:

- 1. Curcumin is now well established therapeutic agent against cancer, neurodegenerative diseases, microbial infections, arthritics and other inflammatory disorders.
- 2. It has hepatoprotective, immune-enhancer, cardiovascular and gastrointestinal effects

SICAL PROPERTIES:		
PROPERTIES	ETHYL PROPIONATE	CURCUMIN
Molecular formula	<i>C</i> ₅ <i>H</i> ₁₀ <i>O</i> ₂	$C_{21}H_{20}O_{6}$
Molecular weight	102.133 g/mol	368.38g/mol
Melting point	-73.6°c(-100.5°F;199.6k)	183°c(361.4°F;456.15k)
Boiling point	78.9°c(210.0°F;372.0k)	591.4°c(1096.52°F;864.55k)
Appearance	Colourless liquid	Yellowish liquid
Density	0.884325 g/cm ³	1.3±0.1g/cm ³

PHYSICAL PROPERTIES:

Table (3.1) Physical properties of Ethyl Propionate and curcumin.

ULTRASONIC INTERFEROMETER

THEORY:

Ultrasonic interferometer is a simple and direct device which yields accurate and consistent data, from which one can determine the velocity of ultrasonic sound in a liquid medium with a high degree of accuracy. A crystal controlled interferometer with operating frequencies ranging from 1 to 3 MHz has been used to measure the ultrasonic velocity.

ULTRASONIC DEFINITION:

Ultrasonic sound refers to sound pressure with a frequency greater than the human available range (20 Hz to 20 KHz). When an ultrasonic wave propagates through a medium, the molecules in that medium vibrate over short distance in a direction parallel to the longitudinal wave. During this vibration, momentum is transferred among molecule. This causes the wave to pass through the medium.

ULTRASONIC INTERFEROMETER:



Plate (3.1) Ultrasonic Interferometer.

An Ultrasonic Interferometer is a simple and direct device to determine the ultrasonic velocity in liquid with a high degree of accuracy. It is simple in design, rugged and gives very accurate and reproducible results. Experiments may be performed over a wide range of temperature from -30 °C to +80 °C on all liquids except those which reacts with the plating of cell and crystal. Nearly 10 ml of experimental liquid is required. There is no danger of any change such as deploymerization, due to ultrasonic effect since a very small ultrasonic energy is required. In an ultrasonic Interferometer, the ultrasonic waves are produced by the piezoelectric methods. At a fixed frequency variable path Interferometer, the wavelength of the sound in an experimental liquid medium is measured, and from this one can calculate its velocity through the medium. The ultrasonic cell consists of a double walled brass cell with chromium plated surfaces having a capacity of 10ml. The double wall allows water circulation around the experimental liquid to maintain it at a known constant temperature. The micrometer scale is marked in units of 0.05 mm and has an overall length of 25 mm. Ultrasonic waves of known frequency are produced by a quartz crystal which is fixed at the bottom of the cell. There is a movable metallic plate parallel to the quartz plate, which reflects the waves. The waves interfere with their reflections, and if the separation between the plates is exactly an integer multiple of half wavelength of sound, standing

waves are produced in the liquid medium. Under these circumstances, acoustic resonance occurs. The resonant waves are a maximum in amplitude, causing a corresponding maximum in anode current of the piezoelectric generator.

WORKING PRINCIPLE:

The principle used in the measurement of velocity is based on the accurate determination of the wavelength in the medium. Ultrasonic waves of known frequency (f) are produced by quartz crystal fixed at the bottom of the cell. These waves are reflected by a movable metallic plate kept parallel to the quartz crystal. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator driving the quartz crystal and anode current of the generator become a maximum. If the distance is now increased or decreased and the variation is exactly one-half wavelengths or multiple of it, anode current become maximum. From the knowledge of wavelength, the velocity can be obtained by the relation;

Velocity = Wavelength × Frequency

 $V = \lambda \times f$

ADJUSTMENT OF ULTRASONIC INTERFEROMETER:

For initial adjustment two knobs are provided on high frequency generator, one is marked with "ADJ" to adjust the position of the needle on the ammeter and the knob marked "GAIN" is used to increase the sensitivity of the instrument for greater deflection, if desired. The ammeter is used to notice the number of maximum deflection while micrometer is moved up or down in liquid.

PROCEDURE:

Unscrew the knurled cap of cell and lift it away from double walled construction of the cell. In the middle position of it pour experimental liquid and screw the knurled cap. Wipe out excess liquid over flowing from the cell.

Insert the cell in the heavy base socket and clamp it with the help of a screw provided on its side. Connect the high frequency generator with cell by coaxial cable provided with the instrument. In ultrasonic Interferometer frequency selector knob should be positioned at desired frequency (same frequency as that of liquid cell chosen). Move the micrometer slowly in either clockwise or anticlockwise direction till the anode current on the ammeter on the high frequency generator shows a maximum or minimum. Note the reading of micrometer corresponding to the maximum or minimum (which is sharper) in micro ammeter. Take about 50 reading of consecutive maximum or minimum and tabulate them. Take average of all differences ($\lambda/2$). Once the wavelength (λ) is known the velocity (V) in the liquid can be calculated with the help of the relation.

MEASUREMENT OF THE DENSITY:

The density measurement was made by specific gravity bottle. The specific gravity bottle was initially rinsed using acetone (cleaning agent). The weight of the specific bottle was measured. Then the weight of the specific gravity bottle with the liquid was measured. From the weight measurement the density of the liquid was calculated.

Density = M/V (kg/m³)

Where,

M = mass in kg.

V = volume in m^3 .

M = Mass of the specific gravity bottle with liquid – Mass of the

empty specific gravity bottle.



Plate:3.2 (a) Specific gravity bottle



Plate :3.2 (b) Specific gravity bottle with liquid mixture

MEASUREMENT OF VISCOSITY:

The viscosity measurements were done through Ostwald's viscometer. The viscometer is filled with reference liquid (distilled water). Using a suitable arrangement, the water is sucked above the marked level and then it is allowed to flow freely. The water is replaced with a mixture, whose viscosity is to be determined. Using the same procedure, the time taken for flow of liquid mixture at the experimental temperature was determined. Using the time taken for the distilled

water and mixture, the viscosity of unknown liquid mixture is determined:

$$\eta = \rho t \times \frac{\eta_0}{\rho_0 t_0} \quad (\text{Nsm}^{-2})$$

Where,

 ρ = density of a liquid in kg/ m^3

t = temperature constant

 $\eta_0 = \text{coefficient}$ of viscosity of water in \textit{Nsm}^{-2}

 $t_0 = time taken by the water in s$

 ρ_0 = density of water in Kg/m³



Plate: 3.3 Ostwald's Viscometer

Viscosity is an important transport property for process design in petroleum, petrochemical, chemical and other chemical industries involving fluid transportation, mixing agitation, heat exchange and concentration. The estimation of the viscosity of a mixture is more difficult than of the pure compound.

ADIABATIC COMPRESSIBILITY:

The adiabatic compressibility is the fractional decrease of volume per unit increase of pressure, when no heat flows in or out. These changes are related to the compressibility of the medium by thermodynamic relation.

$$\beta_{\alpha} = \frac{1}{V^2 \rho} \quad (m^2 N^{-1})$$

Where,

V = ultrasonic velocity of a liquid in m/s.

 ρ = density of a liquid in Kg/ m^3 .

FREE LENGTH:

The free length is the distance covered by sound wave between the surfaces of the neighbouring molecules. It is measure of intermolecular attractions between the components in binary mixture. The increase of decrease in free length indicates weakling and strengthen of intermolecular attraction. As the ultrasonic velocity increase due to the increases in concentration, the interaction free length has to decrease and vice-versa. It is related to ultrasonic velocity and density as

$$L_{f} = \frac{KT}{V\rho^{\frac{1}{2}}} \quad (kgms^{-2})$$

Where,

K = temperature constant V = velocity of liquid in m/s

 ρ = density of a liquid Kg/ m^3

The compressibility of a liquid can be expressed in terms of the intermolecular free length which is the distance between the surfaces of the neighbouring molecules.

RELAXATION TIME:

Relaxation times is the time taken for the excitation energy to appear as translational energy and it depends on temperature and on impurities. The dispersion of the ultrasonic velocity in binary mixture reveals information about the characteristic time of the relaxation process that causes dispersion. The relaxation time (τ) can be calculated from the relation;

$$\tau = \frac{4}{3}\beta_a\eta \quad (s)$$

Where,

 β_a = adiabatic compressibility of a liquid in $m^2 N^{-1}$

 η = coefficient of viscosity of a liquid in Ns m^{-2}

ACOUSTIC IMPEDANCE:

Sound travels through materials under the influence of sound pressure. Because molecules or atoms of a solid are bound elastically to one another, the excess pressure results in wave propagation through the solid.

The acoustic impedance (Z) of a materials is defined as the products of its density (ρ) and ultrasonic velocity (v) given as,

$$Z = V\rho$$
 (Kgm⁻²s⁻¹)

Where,

V = velocity of a liquid in m/s

 ρ = density of a liquid in Kg/ m^3

ULTRASONIC ATTENUATION:

The amplitude and intensity of ultrasonic waves decrease as they travel through tissue, this phenomenon is known as attenuation. For a given fixed propagation distance, attenuation affects the high frequency ultrasound waves to a greater degree than lower frequency waves. The ultrasonic attenuation (α/f^2) can be calculated from the relation,

$$\frac{\alpha}{f^2} = \frac{8\pi^2\eta}{3\rho V^2} \quad \left(\frac{Np}{ms^2}\right)$$

Where,

 η = coefficient of viscosity of a liquid in Nsm⁻²

 ρ = density of a liquid in kg/ m^3

CHAPTER – IV

RESULT AND DISCUSSION :

Velocity of 3MHz ultrasonic wave in pure liquids, densities and viscosities of Ethyl propionate with curcumin were measured with pre calibrated interferometer, Density bottle and viscometer respectively to nearest mg in the room temperature or tabulated. The values of derived parameters such as velocity (v), density (ρ), viscosity (η), adiabatic compressibility (β), free length (L_f), acoustical impedance (Z), relaxation time(ι) and ultrasonic attenuation (α/f^2) are calculated using standard relations and are tabulated.

Serial	Percen	itage%	
no.	Ethyl	Curcumin	Velocity (v)
	Propionate		(m/s)
1	99	1	1440
2	98	2	1380
3	97	3	1449
4	96	4	1320
5	95	5	1380
6	94	6	1380
7	93	7	1320
8	92	8	1380
9	91	9	1338
10	90	10	1440

Table (4.1): Value of experimental parameter: Velocity (v)



Figure: (4.1) Experimental parameter: Velocity (v)

Ultrasonic velocity (v) was found to increase for 1%, 3% and 10% of curcumin. It was found to be equal for 2%, 5%, 6% and 8% of curcumin. It was found more or less equal and lesser for 4%, 7% and 9% of curcumin. Table (4.1)

	Percen	Density (p)	
Serial	Ethyl	Curcumin	(Kg/m ³)
no.	Propionate		
1	99	1	917.6
2	98	2	892.4
3	97	3	893.2
4	96	4	903.2
5	95	5	909.2
6	94	6	877.8
7	93	7	898.4
8	92	8	898.8
9	91	9	906.6
10	90	10	907.8

Table (4.2): Value of experimental parameter: Density (ρ)



Figure: (4.2): Experimental parameter: Density (p)

Density (ρ) was found to be maximum for 1% of curcumin and minimum for 6% of curcumin. It was found to have equal values for 2% and 3% of curcumin. Similarly, for 4%, 7% and 8% of curcumin values of density were found to be equal. For 5%,9% and 10% of curcumin values were found to be more or less equal. Table (4.2)

	Percen	ntage%	Coefficient of Viscosity (η)	
Serial	Ethyl	Curcumin	(10^{-5}) (Nsm ⁻²)	
no.	Propionate			
1	99	1	0.5300	
2	98	2	0.5155	
3	97	3	0.5253	
4	96	4	0.5122	
5	95	5	0.5347	
6	94	6	0.5070	
7	93	7	0.5095	
8	92	8	0.5192	
9	91	9	0.5237	
10	90	10	0.5240	

Table (4.3): Value of experimental parameter: Coefficient of Viscosity (η)



Figure: (4.3): Experimental parameter: Coefficient of Viscosity(η)

Value of viscosity (η) was found to be maximum for 5% of curcumin and lowest for 6% of curcumin. It was found to have more or less equal values for 2%, 4% and 7% of curcumin. Similarly, for 1%,3% and 8% of curcumin values were found to be more or less equal for viscosity. For mixtures with 9% and 10% of curcumin, values were found to be equal for viscosity. Table (4.3)

G 1 1	Percentage %			
Serial no. Ethyl Curcumin Propionate	Adiabatic Compressibility (β_{α}) (10 ⁻¹⁰) (m ² N ⁻¹)			
1	99	1	5.2555	
2	98	2	5.8841	
3	97	3	5.3322	
4	96	4	6.3543	
5	95	5	5.7754	
6	94	6	5.9819	
7	93	7	6.3822	
8	92	8	5.8422	
9	91	9	6.1612	
10	90	10	5.3123	

Table (4.4): Value of derived parameter: Adiabatic Compressibility (β_a)



Figure: (4.4): Derived parameter: Adiabatic Compressibility (β_a)

Adiabatic Compressibility (β_a) was found to have the highest values for 4%, 7% and 9% of curcumin. It was found to be more or less equal in 2%, 5%, 6% and 8% of curcumin. Lowest values were found for 1%, 3% and 10% of curcumin for adiabatic compressibility. Table (4.4)

	Percentage%		
Serial no.	Ethyl Bronionata	Curcumin	Free Length (L_f) (10 ⁻¹⁰) (Kgms ⁻²)
1	99	1	0.4548
2	98	2	0.4812
3	97	3	0.4518
4	96	4	0.5001
5	95	5	0.4768
6	94	6	0.4852
7	93	7	0.5014
8	92	8	0.4795
9	91	9	0.4924
10	90	10	0.4573

Table (4.5): Value of derived parameter: Free Length (L_f)



Figure: (4.5): Derived parameter: Free Length (L_f)

In Free length (L_F) higher values were reported for 4% and 7% of curcumin. It was found to have lower values for 1%,3% and 10% of curcumin. It was found to be more or less equal for 2%,5%, 6%,7%,8% and 9% of curcumin. Table (4.5)

Carriel	Percen	itage%		
Serial no. Ethyl Propionate	Curcumin	Acoustic Impedance (Z) (10^6) (Kg m ⁻² s ⁻¹)		
1	99	1	1.3213	
2	98	2	1.2315	
3	97	3	1.2942	
4	96	4	1.1922	
5	95	5	1.2546	
6	94	6	1.2113	
7	93	7	1.1858	
8	92	8	1.2403	
9	91	9	1.2130	
10	90	10	1.3072	

Table (4.6): Value of derived parameter: Acoustic Impedance (Z)



Figure: (4.6): Derived parameter: Acoustic Impedance (Z)

Acoustic Impedance (Z) was found to increase in 1%, 3% and 10% of curcumin. It was found to decrease in values for 4% and 7% of curcumin. It was found to have more or less equal values for 5% and 8% of curcumin. Similarly, 2%,6% and 9% of curcumin were found to have more or less equal values. Table (4.6)

	Percer	ntage %		
Serial	Ethyl	Curcumin	Relaxation Time (1)	
no.	Propionate		(10^{-12}) (s)	
1	99	1	0.3713	
2	98	2	0.4044	
3	97	3	0.3734	
4	96	4	0.4339	
5	95	5	0.4117	
6	94	6	0.4043	
7	93	7	0.4339	
8	92	8	0.4044	
9	91	9	0.4302	
10	90	10	0.3711	

Table (4.7): Value of derived parameter: Relaxation Time (1)



Figure: (4.7): Derived parameter: Relaxation Time (1)

Relaxation Time (1) was found to be maximum for 4%, 7% and 9% of curcumin. It was found to have minimum values for 1%,3% and 10% of curcumin. It was found to have more or less equal values for 2%,5%,6% and 8% of curcumin. Table (4.7)

a . 1	Percent	tage %	
Serial no. Ethyl Curcu Propionate	Curcumin	Ultrasonic Attenuation ($\alpha/1^2$) (10 ⁻¹³) (Np/ms ²)	
1	99	1	0.7323
2	98	2	0.7975
3	97	3	0.7364
4	96	4	0.8557
5	95	5	0.8119
6	94	6	0.7974
7	93	7	0.8557
8	92	8	0.7975
9	91	9	0.8483
10	90	10	0.7318

Table (4.8): Value of derived parameter: Ultrasonic Attenuation (α/f^2)



Figure: (4.8): Derived parameter: Ultrasonic Attenuation (α/f^2)

Ultrasonic Attenuation (α/f^2) was found to have the highest values for 4%,7% and 9% of curcumin. It was found to have the lowest values for 1%,3% and 10% of curcumin. It was found to be more or less equal for 2%, 5%, 6% and 8% of curcumin. Table (4.8)

CHAPTER -V

CONCLUSION:

The ultrasonic velocity (v) density (ρ) and viscosity (η) have been measured for experimental liquid mixture of Ethyl propionate with curcumin .From these data few acoustical parameters such as Adiabatic compressibility (β_{α}), Free length (L_f),Relaxation time (i), Acoustical impedance (Z) and Ultrasonic attenuation (α/f^2) have been computed using standard relations .The variation in ultrasonic velocity and other parameters play significant role in understanding the solvent – solvent, intra and intermolecular interactions between the constitute molecules.

	Percentage%				
Serial	Ethyl	Curcumin	Velocity (v)	Density (ρ)	Coefficient of Viscosity (η)
no.	Propionate		(m/s)	(Kg/m^3)	(10^{-3}) (Nsm ⁻²)
1	99	1	1440	917.6	0.5300
2	98	2	1380	892.4	0.5155
3	97	3	1449	893.2	0.5253
4	96	4	1320	903.2	0.5122
5	95	5	1380	909.2	0.5347
6	94	6	1380	877.8	0.5070
7	93	7	1320	898.4	0.5095
8	92	8	1380	898.8	0.5192
9	91	9	1338	906.6	0.5237
10	90	10	1440	907.8	0.5240

Table (5.1): Values of experimental parameters: v, ρ , η

a	Perce	ntage %					
Serial no.	Ethyl Propionate	Curcumin	Adiabatic Compressibility (βa) (10 ⁻¹⁰) (m ² N ⁻¹)	Free Length (L_f) (10^{-10}) (Kgms ⁻²)	Acoustic Impedance(Z) (10^6) (Kg m ⁻² s ⁻¹)	Relaxation Time(ι) (10 ⁻¹²) (s)	Ultrasonic Attenuation (α /f ²) (10 ⁻¹³) (Np/ms ²)
1	99	1	0.4548	1.3213	0.3713	0.7323	5.2555
2	98	2	0.4812	1.2315	0.4044	0.7975	5.8841
3	97	3	0.4518	1.2942	0.3734	0.7364	5.3322
4	96	4	0.5001	1.1922	0.4339	0.8557	6.3543
5	95	5	0.4768	1.2546	0.4117	0.8119	5.7754
6	94	6	0.4852	1.2113	0.4043	0.7974	5.9819
7	93	7	0.5014	1.1858	0.4339	0.8557	6.3822
8	92	8	0.4795	1.2403	0.4044	0.7975	5.8422
9	91	9	0.4924	1.2130	0.4302	0.8483	6.1612
10	90	10	0.4573	1.3072	0.3711	0.7318	5.3123

Table 5.2 :- Values of derived parameters : $\beta_{a,}\,L_{f},\,Z,\,\iota,\,\alpha/f^{2}$

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METHODOLOGY OF GRID SOLAR SYSTEMS

Project report submitted to the Department of Physics,

ST. MARY'S COLLEGE (AUTONOMOUS), THOOTHUKUDI.

Affiliated to

Manonmaniam Sundaranar University, Tirunelveli

In partial fulfilment of the requirement for the award of

BACHELOR'S DEGREE IN PHYSICS

By

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(Re-accredited with 'A+' Grade by NAAC),

2021-2022

CERTIFICATE

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EXAMINER



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Abstract

Solar energy has incredible potential to power our daily lives. Researchers suggest that the amount of sunlight that strikes the Earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year.

Solar power system is one of the best renewable energy technologies which is not only cost effective but environment friendly as well. For our research, we have suggested methodologies that may be applicable to get a maximum power output. The power will vary based on the temperature and climatic conditions. Higher the radiation of the sun, higher will be the output power.

This paper will focus on the output power and current of various panels(Panel-1 and panel-2) along with or without resistances (R1 and R2). The main aim of this project is to determine the circuit in which particular circuit the power turns maximum, so that it could be applicable to various future trends of PV system to obtain the best efficiency by solar energy.

CHAPTER-1

GENERAL THEORY, WORKING AND

PRINCIPLE OF SOLAR PANELS

Introduction

Energy is a necessity like food and water. Everything around us requires energy. Over the years, there has been an increase in the earth's population which is directly proportional to the energy used as well. All the possible gadgets and equipment need some or the other kind of energy to function. With depleting fossil fuel reserves, it becomes necessary to identify viable renewable energy resources that can decrease the dependency on fossil fuels.

A solar cell is a device that converts light into electricity via the 'photovoltaic effect'. They are also commonly called 'photovoltaic cells' after this phenomenon, and also to differentiate them from solar thermal devices. The photovoltaic effect is a process that occurs in some semiconducting materials, such as silicon. At the most basic level, the semiconductor absorbs a photon, exciting an electron which can then be extracted into an electrical circuit by built-in and applied electric fields.



Solar energy is the most abundant form of energy available to us. It is approximated that 10000 TW worth of solar energy is incident on earth's surface in a day. According to a report, the world energy consumption in 2015 was 17.4 TW altogether (Seger, 2016). There has been a minimal increase in the energy consumption every year, approximately 1-1.5% annual growth. The world's total energy consumption is expected to grow by 56% by the year 2040 (U.S Energy Information Administration, 2013. The total energy consumed is not a small fraction of what we receive in an hour.

Despite this energy potential available to us, the current utilization of solar energy is less than 5% globally. There are countries that are taking initiatives to switch from using fossil fuels to solar applications. These countries form a pool called the G-20 countries which have taken the global leadership to adopt renewable resources of energy. Germany is one of the G 20 countries that has switched its energy needs to approximately 38% to solar and aim to completely stop it dependency on nuclear and replace it with solar power.

Apart from harvesting the resource and decreasing the dependency on fossil fuel because they are limited, one must understand the consequences of using fossil fuels. Burning of fossil fuels for energy has an adverse effect on the environment. It releases CO_2 into the atmosphere which is responsible for the greenhouse effect. Further, it also causes the ozone layer to be depleted. These mentioned phenomena can cause several events to occur such as; acid rain, air pollution, land pollution because of excavating operations, etc.

General theory

The main component of a solar cell is the semiconductor, as this is the part that converts ight into electricity. Semiconductors can carry out this conversion due to the structure of their electron energy levels. Electron energy levels are generally categorized into two bands: the 'valence band' and the 'conduction band'. The valence band contains the highest occupied electron energy levels, whilst the conduction band contains the lowest unoccupied electron energy levels. The energy difference between the top of the valence band and bottom of the conduction band is known as the 'band gap' (Eg). In a conductor, there is no band gap as the valence band is not filled completely - thus allowing the free movement of electrons through the material. Insulators have very large band gaps which require copious amounts of energy to cross – and as such, inhibits the movement of electrons from the valence band to the conduction band.



This small band gap is what enables some semiconductors to generate electricity using light. If a photon incident on the semiconductor has energy $(E\gamma)$ greater than the band gap, it will be absorbed - enabling an electron to transfer from the valence band to the conduction band. This process is known as 'excitation'. With the electron now in the conduction band, an unoccupied state is left in the valence band.

This is known as a 'hole' and behaves like a particle analogous to an electron in the conduction band (albeit with positive charge). Due to their opposite charge, the excited electron and hole are coulombically bound in a state known as an 'exciton'. This exciton must be split (also known as 'dissociation') before the charge carriers can be collected and used. The energy required to do this is dependent on the dielectric constant (ε_r) of the material. This describes the level of screening between charges in a semiconducting material and affects the binding energy of the exciton.



n materials with high ε_r , excitons have low binding energies - enabling dissociation to occur thermally at ambient temperatures. Excitons in materials with low ε_r have high binding energies, preventing thermal dissociation – thus requiring a different method of dissociation. A common method is to get the exciton to an interface between materials with energy levels that have an offset greater than the exciton's binding energy.





Once dissociated, the free charges diffuse to the electrodes of the cell (where they are collected) - this is assisted by built-in and applied electric fields. The built-in electric field of a device arises from the relative energy levels of the materials that make up the cell. However, the origin of the built-in field depends on the type of semiconductor being used. For inorganic semiconductors such as silicon, other materials are often added to the semiconductor (a process known as doping) to create regions of high (ntype) and low (p-type) electron density. When these regions are in contact, charges will build up on either side of the interface, creating an electric field directing from the ntype to the p-type region. In devices using organic semiconductors, the built-in field arises from the difference between the work functions of the electrodes of the device. The size of the band gap is also very important, as this affects the energy that can be harvested by the solar cell. If $E_{\gamma} > E_{g}$, then the photon will be absorbed and any energy in excess of Eg will be used to promote the electron to an energy level above the conduction band minimum. The electron will then relax down to the conduction band minimum, resulting in the loss of the excess energy. However, if $E_{\gamma} < E_{g}$, then the photon will not be absorbed, again resulting in lost energy. (Note, the wavelength of a photon decreases as its energy increases).

Photovoltaic Cells

In the 18th century, Swiss Physicists assembled a warm trap, which was a small-scale greenhouse. He developed a hot box, by a glass box in another larger glass box, a total of up to five boxes. When they were proposed to coordinate the sun's illumination, the temperature in the deepest box could be raised to 108 degrees celsius; warm enough to soak water and cook food. These crates can be considered the world's first solar collection.

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of photons that are incident on it to electrical energy, which is a natural and synthetic marvel. A separate cell unit can be connected to a frame module, also known as a solar panel. Different solar cells in a unified set, all arranged in the plane represents a solar photovoltaic board or module. PV modules usually have a glass in front of the panel, allowing light to pass through, while ensuring that the semiconductor plate is protected inside the case. Solar cells are usually associated, and arranged in series or parallel module, depending upon the requirement of the customer. The parallel interface unit gets higher current; however, the problem, for example, that shadow effects can turn off weaker (less bright) parallel strings (different permutations of cells) can cause great unpleasant effects and may cause damage because of their enlightened complicity and the reversal of dark cell tendencies. A series of stacked units are usually autonomous and not parallel, but starting from 2014, each module provides a singular power box on a regular basis and connects in parallel.

Working Principle of Solar Panels:

In the previous discussion, it has been established that there is abundance of solar energy available to be harvested. A brief discussion of what PV cells is also being covered. It is necessary that we understand how these cells generate electricity so that we can design systems that can be in tandem with these basic concepts. The following discussion will explain how the cells generate electricity.

Sun is a power house of energy and this energy moves around in the form of electromagnetic radiations. These radiations are of several types such as light, radio waves, etc. depending upon the wavelength of the radiations emitted. A very less percentage of sun's radiations reach the earth's atmosphere in the form of visible light. Solar cells use this visible light to make electrons. Different wavelengths of light are used by different solar cells.

Principle: Solar cells are made up of semiconductor materials, such as silicon, which is used to produce electricity. The electricity is conducted as a stream of tiny particles called electrons and the stream is called electric current. Two main types of electric currents are; DC (direct current) in which the flow of current is in the same direction while in AC (Alternating current) it may reverse the direction of current. A typical solar cell has two layers of silicon, which is n-type at the top and p-type at the bottom. When sunlight strikes the solar cell, the electrons are absorbed by silicon, they flow between n and p-layers to produce electric current and the current leaves the cell through the metal contact. The electricity generated is of AC type.



The table below shows the best research cell efficiencies for a variety of photovoltaic technologies (values courtesy of the National Renewable Energy Laboratory, Golden, CO).

Solar Cell Type	Highest Efficiency (Research)
Monocrystalline silicon (mono-Si)	25.3%
Polycrystalline silicon (multi-Si)	21.9%
Amorphous silicon (a-Si)	14.0%
Monocrystalline gallium arsenide (GaAs)	28.8%
Cadmium telluride (CdTe)	22.1%
Copper indium gallium selenide (CIGS)	22.6%
Dye-sensitised (DSSC)	11.9%
Organic (OSC)	11.5%
Perovskite (PSC)	22.1%

CHAPTER-2

SOLAR RADIATION AND

ITS MEASUREMENTS

Introduction:

In general, the energy produced and radiated by the sun more specifically the terms refer to the sun's energy that reaches the earth. Solar energy, received in the form of radiation, can be converted directly or indirectly into other forms of energy, such as heat and electricity, which can be utilized by man. Since the sun is expected to radiate at an essentially constant rate for a few billion years, it may be regarded as an-exhaustible source of useful energy. The major drawbacks to the extensive application of solar energy are:

1. The intermittent and variable manner in which it arrives at the earth's surface and

2. The large area required to collect the energy at a useful rate. Experiments are underway to use this energy for power production, heating, air conditioning, cooking and high temperature melting of metals

Energy is radiated by the sun as electromagnetic waves of which 99 percent have wavelength in the range of 0.2 to 0.4 micrometer (1 micrometer $=10^{-6}$ meter). Solar energy reaching the top of the earth's atmosphere consists of about 8 percent ultraviolet radiation (short wavelength, less than 0.39 micrometer), 46 per cent infrared radiation (long wavelength more than 0.78 micrometer)

Solar constant:

The sun is a large sphere of very hot gases, the heat being generated by various kinds of fusion reactions. Its diameter is 1.39×10^6 km. while that of the earth is 1.27×10^4 km. The mean distance between the two is 1.50×10^8 km. although the sun is large, it subtends an angle of only 32 minutes at the earth's surface. This is because it is also at a very large distance. Thus the beam radiation received from the sun on the earth is almost parallel. The brightness of the sun varies the spectral distribution of solar radiation intensity.



Radiation obtained up to a certain wavelength is also given in the table

Wavelength (m)	0-0.38	0.38-0.78	0.78-4.0
Approximate energy (W/m ²)	95	640	618
Approximate percentage of total energy	7%	47.3%	45.7%

Solar Radiation at the Earth's Surface:

From the point of view of utilization of solar energy we are more interested in the energy received at the earth's surface than in the extra-terrestrial in the energy. Solar radiation received at the surface of the earth is entirely different due to the various reasons. Before studying this it is important to know the following terms:

Beam and Diffuse Solar Radiation:

The solar radiation that penetrates the earth's atmosphere and reaches the surface differs in both amount and characters from the radiation at the top of the atmosphere. In the first place, part of the radiation is reflected back into the space, especially by clouds. The radiation entering the atmosphere is partly absorbed by molecules in the air. Oxygen and ozone, formed from oxygen, absorb nearly all the ultraviolet radiation, and water vapor and carbon dioxide absorb some of the energy in the infrared range. In addition, part of the solar radiation is scattered by droplets in clouds by atmospheric molecules, and by dust particles.

Solar radiation that the not been absorbed or scattered and reaches the ground directly from the sun is called "Direct Radiation" or "Beam Radiation". It is the radiation which produces a shadow when interrupted by an opaque object. Diffuse radiation is that solar radiation received from the sun after its direction has been changed by reflection and scattering by the atmosphere, because of the solar radiation is scattered in all directions in the atmosphere, diffuse radiation comes to the earth from all parts of the sky.

The total solar radiation received at any point on the earth's surface is the sum of the direct and diffuse radiation. This is referred to in a general sense as the insolation at the point. More specifically, the insolation is defined as the total solar radiation energy received on a horizontal surface of unit area on the ground in unit time.

The insolation at a given location on the earth's surface depends, among other factors on the altitude of the sun in the sky. (the altitude is the angle between the sun's direction and the horizontal). Since the sun's altitude changes with the data and time of the day and with the geographic latitude at which the observations are made, the rate of arrival of solar radiation on the ground is variable quantity even in the time. There are, nevertheless, some general points that can be made.

The smaller the sun's altitude, the greater the thickness of atmosphere through which the solar radiation must pass the reach the ground. As a result of absorption and scattering, the insolation is less when the sun is low in the sky than when it is higher. However, when scattering occurs, diffuse radiation constitutes a larger fraction of the total received. On a clear, cloudless 10 to 20 percent of the insolation is from diffuse radiation the proportion increases upto 10 percent when the sun is completely obscured by clouds. When the humidity is high, the insolation on a cloudy day, consisting entirely of diffuse radiation, may be as high as 50 percent of the insolation on a clear day at the same time and place.

Sun at zenith: Position of the sun directly over head.

Air mass (m): It is the path length of radiation through the atmosphere, considering the vertical path at sea level as unity. The air mass m is the ratio of path of the sun's rays through the atmosphere to the length of path when the sun is at the zenith. Expect for very low solar altitude angles, air mass is equal to the cosecant of the altitude angles. Thus at sea level m=1.

m=l	when the sun is zenith, i.e. directly head.
m=2	when zenith is 60°
m=sec θ_z	when m>3 (Θ_z , the angle subtended by the zenith
	and the line of sight to the sun)
m = 0	just above the earth's atmosphere.

Attenuation of Beam Radiation:

The variation in solar radiation reaching the earth than received at the outside of the atmosphere is due to absorption and scattering in atmosphere.

Absorption:

As solar radiation passes through the earth's atmosphere the short-wave ultraviolet rays are absorbed by the ozone in the atmosphere and the long wave intra-red waves are absorbed by the carbon dioxide and moisture in the atmosphere.

This results in the narrowing of the bandwidth. In fact most of the terrestrial solar energy (i.e. energy received by the earth) lies within the range of 0.26 μ m to 2.5 μ m.

Scattering:

As solar radiation passes through the earth's atmosphere, the components of the $a_{tmosphere}$, such as water vapor and dust, scatter a portion of the radiation. As portion of this scattered radiation always reaches the earth surface as diffuse radiation. Thus the radiation finally received at the earth surface consists partly of beam radiation and partly of diffuse radiation.

It must be realized that scattering attenuates the radiation. The exact amount of scattering and consequential attenuation depends on the atmosphere conditions which vary from place to place and at a given place depends on the time of the day, the month of the year and the local weather.

 O_{20} absorbs mainly in the ultraviolet band. It absorbs almost completely the short wave radiation below 0.29μm and transmitted is almost unity above wavelength of 0.35μm. water vapor absorbs mainly in the infrared bands. At wavelength lower than 2.3μm, the extra terrestrial solar radiation by H₂O and CO₂ in atmosphere, is strong. Hence for terrestrial applications of solar energy, only wave length between 0.29 and 2.5μm need be considered.



The above diagram shows the spectral distribution curve. Under favorable atmospheric conditions, the maximum intensity observed at noon on an oriented surface at sea level $_{\rm is}$ 1 KW/m². At an altitude of 1000 meters, the value rises to about 1.05KW/m², and in higher mountains, values slightly above 1.1 KW/m² are obtained, compared with 1.353 KW/m^2 (the solar constant) in outer space. The latter value is sometimes called air mass 0(AM0), whereas at sea level, the maximum possible intensity is called AM1. The upper curve applies at the outer limit of the atmosphere (AM0). The other lower curve applies at the earth's surface during clear days for a sea level location for AM1. Dotted curve shows curve for a black body at 5900 K. The lower two curve are diffuse components for some haze and clear sky conditions respectively. Considering the solar tradiation curve or lower and upper curve case, the atmospheric transmission factor is given as the area under lower curve (solar constant). For m= 5.0, at the earth surface sea level, the transmission factor is 0.276. For different value of m, the transmission factor can be determined. Thus, the length of the sun in affecting reduction of solar intensity.

Solar Radiation Geometry: The angles of solar radiation analysis are

- ϕ_1 = latitude of location
- r = declination
- ω = hour angle
- $\gamma_s = \text{solar azimuth angle}$
- s = slope
- α = altitude angles
- θ_z = zenith angles.

If e is the angles between an incident beam radiation, I and the normal to the plane surface, then the equivalent flux or radiation intensity falling normal to the surface is given by I cos e, where, e is called incident angle.

Solar Radiation Measurements: Measurements of solar radiation are important because of the increasing numbers of solar heating and cooling applications and the need of accurate solar irradiation of the energy transferred to a surface by solar radiation required instruments which will measure the heating effect of direct solar radiation and diffuse solar radiation. Measurements are also made of beam radiation, which responds to solar radiation received from a very small portion of the circum solar sky. A total radiation type of instruments may be used for measuring diffuse radiation along by shading the sensing elements from the sun's direct rays.

A pyrheliometer, which collimates the radiation to determine the beam intensity as a function of incident angles, and

A pyranometer, which measure the total hemispherical solar radiation. The pyranometer measurements are the most common. The total solar radiation arriving at the outer edge of the atmosphere is called the solar constant as already mentioned.

Pytheliometer:

A pytheliometer is an instrument which measures beam radiation. In contract to a pytheliometer, the sensor disc is located at the base of a tube whose axis is aligned with the direction of the sun's ray. Thus diffuse radiation is essentially blocked from the sensor surface.

Most pyrheliometers used for routine measurements operate on the thermopile effect and are similar to pyranometer in this respect. They differ mechanically that they must follow the sun to measure only direct sunlight and avoid the diffuse components. In practice, direct solar radiation is measured by attaching the instruments to an electrically driven equatorial mounts for tracking the sun. The diffuse components is avoided by installing a collimator tube over the sensor with a circular cone angles of about 5°. Problems with pyrheliometer measurements are of several fold; the aperture angle, the circum solar contributions and imprecision in the tracking mechanism.

The first two problems are almost impossible the tracking mechanism because of the inability to define the solar disc precisely and the finite dimensions of the components of the instruments. The practical matter of precise taking and sensor orientation are simply great. The use of correction factors in not only involved but somewhat unreliable.

The direct solar components on a horizontal surface may also be obtained using a shading ring. This is done by subtracting the shaded (diffuse) from the unshaded (global) reading.

Current practice in solar radiometry relies primarily on thermoelectric transducers. However, relatively low cost photovoltaic transducers are becoming more popular. To measure the direct solar rays, i.e. a line joining the sun and receiver, three pyrheliometer have been in wide-spread use to measure normal incident beam radiation:

The Angstrom pyrheliometer

The Abbot silver disc pyrheliometer

Eppley pyrheliometer

1.

2.

(i)Angstrom Pyrheliometer: Pyrheliometer is an instrument used to measure the quantity of heat radiation and solar constant. Pyrheliometer designed by Angstrom is the simplest and most accurate. Angstrom's pyrheliometer consists of two identical strips S_1 and S_2 of area A. One junction of a thermocouple is connected to S_1 and the other junction is connected to S_2 . A sensitive galvanometer is connected to the thermo couple.



Strip S_2 is connected to an external electrical circuit as shown in Figure. When both the strips S_1 and S_2 are shielded from the solar radiation, galvanometer shows no deflection as both the junctions are at the same temperature. Now strip S_1 is exposed to the solar radiation and S_2 is shielded with a cover M. As strip S_1 receives heat radiations from the sun, its temperature rises and hence the galvanometer shows deflection. Now current is allowed to pass through the strip S_2 and it is adjusted so that galvanometer shows no deflection. Now, the strips S_1 and S_2 are again at the same temperature.

If the quantity of heat radiation that is incident on unit area in unit time on strip S_1 is Q and a its absorption co-efficient, then the amount of heat radiations absorbed by the strip S_1 in unit time is QAa.

Also, heat produced in unit time in the strip S_2 is given by VI, where V is the potential difference and I is the current flowing through it.

As heat absorbed = heat produced QAa = VI (or) Q=VI/Aa

Knowing the values of V, I, A and a, Q can be calculated.

(ii) Abbot silver disc Pyrheliometer:

It consists essentially of a blackened silver disc positioned at the lower end of a tube with diaphragms to limit the whole aperture to 5.7°. A mercury in glass thermometer is ^{used} to measure the temperature at the disk. A shutter made of three polished metal ^{leaves} is provided at the upper end of the tube to allow solar radiation to fall on the disc

at regular intervals and the corresponding changes in temperature of the disc are measured. The thermometer stem is bent through 90° so that it lies along the tube to minimize its exposure to the sun. The instrument must of course be calibrated against a primary standard, but their stability has been found to be very good and they are widely used for calibrating pyranometers.

(iii) Eppley Pyrheliometer: The sensitive element in an Eppley pyrheliometer is a temperature compensated 15 junction bismuth silver thermopile mounted at the base of a brass tube, the limiting diaphragms of which subtend an angle of 5.7°. A thermopile is basically a series arrangement of thermocouples used to develop a much greater voltage than is possible using only one. The tube is filled with dry air and is sealed with a quartz crystal window which is removable. A filter wheel is standard. It is a stable instrument and can be used as a sub-standard. The instrument has found wide acceptance within the U.S.A. and many parts of the world.

(B) Pyranometers: A pyranometer is an instrument which measures total or global radiation over a hemispherical field of view. If a shading ring is attached, the beam radiation is prevented from falling on the instrument sensor and it then measures only the diffuse component of the radiation. In most pyranometers, the sun's radiation is allowed to fall on a black surface to which the hot junctions of a thermopile are attached. The cold junctions of the thermopile are located in such a way that they do not receive the radiation. As a result, an e.m.f. proportional to the solar radiation is generated.

This e.m.f. which is usually in the range of 0 to 10 mV can be read, recorded or integrated over a period of time with regular calibration of about ± 2 percent can be

obtained.

These are following types of pyranometers:

(1) Eppley pyranometer,

(ii) Yellot solarimeter (photo-voltaic solar cell),

(iii) Moll-Gorczyheski solarimeter,

(iv) Bimetallic Actiono graphs of the Rabitzsch type,

(v) Velochme pyranometer,

(vi) Thermoelectric pyranometer etc.

First two types are described briefly in the following paragraphs.

(i) Eppley pyranometer:

It is based on the principle as stated above that there is a difference between the temperature of black surfaces (which absorb most solar radiation) and white surfaces (which reflect most solar radiation). The detection of temperature difference is achieved by thermopile. It uses concentric silver rings 0.25 mm thick, appropriate coated black and white, with either 10 or 50 thermocouple junctions to detect temperature differences between coated rings. Later models use wedges arranged in a circular pattern, with alternate black and white coatings. The discs or wedges are enclosed in a hemispherical glass cover. Similar instruments are manufactured in Europe under the name Kipp. Pyranometer with alternate black and white sensor segments are calibrated in a horizontal Position. Calibration of these instruments will vary to some degree if the instrument is inclined to measure radiation on other than a horizontal surface. 28

i) Yellot Solarimeter (Photovoltaic solar cell):

pyranometers have also been used on photovoltaic (solar cell) detectors. Silicon cells re the most common for solar energy. Silicon solar cells have the property that their ight current (approximately equal to the short circuit current at normal radiation levels) is a linear function of the incident solar radiation. They have the disadvantage that the pectral response is not linear, so instrument calibration is a function of the spectral listribution of the incident radiation.

unshine Recorder:

The duration of bright sunshine in a day is measured by means of a sunshine recorder. The sun's rays are focussed by a glass-sphere to point on a card strip held in a groove in a spherical bowl mounted concentrically with the sphere.



Whenever there is a bright sunshine, the image formed is intense enough to burn a spot on the card strip. Through the days the sun moves across the sky and the image also ^{noves} along the strip. Thus a burnt space whose length is proportional to the duration of ^{Sun shine} is obtained on the strip.

Solar Radiation Data:

Solar radiation data are available in several forms and should include the following

information.

Whether they are instantaneous measurement or values integrated over some period of time (usually hour or day).

- 2. The time or time period of the measurements.
- 3. Whether the measurements are of beam, diffuse or total radiation, and the instrument

used.

- 4. The receiving surface orientation (usually horizontal, it may be inclined at a fixed slope or normal).
- 5. If averaged, the period over which they are averaged (e.g., monthly average of daily radiation).

Most of the data on solar radiation received on the surface of the earth are measured by solarimeter which give readings for instantaneous measurements at rate throughout the day for total radiation on a horizontal surface. Integrating the plot of rate of energy received per unit area per unit time over a whole day gives the angle of radiation received on a horizontal surface.

CHAPTER-3

OPERATING INSTRUCTIONS OF SOLAR TRAINER KIT

EXPERIMENT WORK

INSTALLATION

- put the Solar panel outside where the clear Sun Light is available
- Connect both Solar Panels to the trainer as shown below:-





- Polarity should be the correct. Incorrect polarity connection may damage the Solar Panel or Inner circuit of Training Panel
- . Now connect Single battery to Battery Terminals as shown below:-



Fig 3.2

- [•] Polarity of Battery should be the correct. Incorrect polarity may damage the Inner circuit of Training Panel and fire hazards may also ^{occur}
- ^{Do} not Short Terminals of Battery or Solar panel
 - Note: Battery should be in full charge condition before doing any experiment

CHARGING OF BATTERY BY SOLAR CHARGE CONTROLLER

procedure:-

- All ON/OFF switches and MCBs should be in OFF position MCBs OFF position is down side and Toggle switches OFF . position is "lever up") Do the connections as shown below:-





Fig 3.3

- Note:- You can connect both Solar panels in Parallel or Series (Parallel & Series Connections are given in Experiment -2) in above diagram both Solar panels are connected in Parallel (by dotted lines)
- Now switch ON the Power Input Switch of training Panel
- Lift Up the MCBs of Battery & Solar PV section
- Solar Panel Voltmeter shows the Voltage of Solar panel and Solar Panel Current Meter shows the Charging Current
- Battery Voltmeter shows the Voltage of Battery
- Leave the system in ON condition to charge the Battery
- In clear Sun light Battery takes 6-7 Hours to be charged

EXPERIMENT-1

1). Voltage Measurement of Solar panel-1

put the Solar panel outside where the clear Sun Light is available

- All ON/OFF switches and MCBs should be in OFF position
- (MCBs OFF position is down side and Toggle switches OFF position is "lever up")
- Do the connections as shown below:-



- · Now switch ON the Power Input Switch of training Panel
- · All meters reading should be zero
- Now Lift Up the MCB of Solar PV section
- Solar Panel Voltmeter shows the Voltage of Solar panel-1

2). Voltage Measurement of Solar panel-2

put the Solar panel outside where the clear Sun Light is available

- All ON/OFF switches and MCBs should be in OFF position
- MCBs OFF position is down side and Toggle switches OFF position is "lever up")

Do the connections as shown below:-





- Now switch ON the Power Input Switch of training Panel
- · All meters reading should be zero
- Now Lift Up the MCB of Solar PV section
- Solar Panel Voltmeter shows the Voltage of Solar panel-2
- •

3).Current Measurement of Solar panel-1

- All ON/OFF switches and MCBs should be in OFF position (MCBs OFF position is down side and Toggle switches OFF position is "lever up")
- Do the connections as shown below:-



- Now switch ON the Power Input Switch of training Panel
- · All meters reading should be zero
- Now Lift Up the MCB of Solar PV section
- · Solar Panel Voltmeter shows the Voltage of Solar panel-1
- Solar Panel Current Meter shows the Current of Solar panel-1 at 20 Ohm DC Resistive Load (Meter shows the Current readings in Milli-Ampere)
- Note: Value of Each Wire Wound Resistance is 10 Ohm. In above connection these resistance are connected in Series so Total Resistance value is 20-Ohm

A).Current Measurement of Solar panel-1

All ON/OFF switches and MCBs should be in OFF position (MCBs OFF position is down side and Toggle switches OFF position is "lever up")

Do the connections as shown below:-



- · Now switch ON the Power Input Switch of training Panel
- · All meters reading should be zero
- · Now Lift Up the MCB of Solar PV section
- · Solar Panel Voltmeter shows the Voltage of Solar panel-1
- Solar Panel Current Meter shows the Current of Solar panel-1 at 20 Ohm DC Resistive Load (Meter shows the Current readings in Milli-Ampere)

^{Note:} - Value of Each Wire Wound Resistance is 10 Ohm. In above connection these ^{Esistance} are connected in Series so Total Resistance value is 20-Ohm

EXPERIMENT-2

Services and Parallel Connection of PV modules

- A).Series Connection All ON/OFF switches and MCBs should be in OFF position (MCBs OFF position is .
 - down side and Toggle switches OFF position is "lever up") Do the connections as shown below:-



Fig 3.8

- Now switch ON the Power Input Switch of training Panel
- · All meters reading should be zero
- · Now Lift Up the MCB of Solar PV section
- · Solar Panel Voltmeter shows the Total Voltage of series connected Solar panels

Note: In series connection voltage of both Panels will be added
B. Parallel Connection All ON/OFF switches and MCBs should be in OFF position All OFF position is down side and Toggle switches OFF (MCBs of the up") position is "lever up") Do the connections as shown below:-



- Now switch ON the Power Input Switch of training Panel
- · All meters reading should be zero
- · Now Lift Up the MCB of Solar PV section
- · Solar Panel Voltmeter shows the Total Voltage of Parallel connected Solar panels
- Note: In Parallel connection Current of both Panels will be added but Voltage will be the same as Single Panel













CHAPTER-4

OBSERVATIONS, GRAPHICAL PICTORIALS AND RESULTS

Preliminary Setup:

First the charging connections are made using the circuits (Fig 3.3). The panel is kept in clear straight for 6-7 hours until the battery gets fully charged. Decrease of voltage below 200V ensures that the battery is fully charged. Next the circuits connecting panel and resistors in different combinations are done and their corresponding voltage and currents are measured.

The values of voltage and current obtained from the solar panels and their combination with resistance R1 and R2.

i Voltage of Panel-1:

The preliminary adjustments are done and the connections are given to measure the voltage in panel-1. It is found that the voltage of panel-1 is 20V.

ii. Voltage of Panel-2:

The preliminary adjustments are done and the connections are given for measuring the voltage in panel-2. The voltage of panel-2 was also similar to the voltage of panel-1 (20)

iii. Voltage of Panel-1 with R1:

The preliminary adjustments are done and the connections are given for measuring the voltage in panel-1 along with the resistance R1. The voltage was found to be 10V and the current was 1340mA. On applying the formula for power is given by,

Power = Voltage (V) x Current (I)

Maximum Power = 10×1340

iv. Voltage of Panel-1 with R2:

The preliminary adjustments are done and the connections are given for measuring the voltage in panel-1 along with the resistance R2. The voltage was found to be 10 V and the ^{current} was 1325 mA. The current obtained in panel-1 with R2 is found to be lesser then ^{panel-1} with R1.

```
Maximum Power = V I
=10 \times 1325 = 13250W
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42

Voltage of Panel-2 with R1:

The preliminary adjustments are done and the connections are given to measure the voltage in panel-2 along with the resistance R1. The voltage was found to be 10 V and the current was 1325 mA.

Maximum Power = VI

 $=10 \times 1325$ =13250 W

vi Voltage of Panel-2 with R2:

The preliminary adjustments are done and the connections are given for measuring the voltage in panel-2 with R2. The voltage was found to be 10 V and the current 1340 mA. The current obtained in panel-2 with R2 is found to be lesser than panel-2 with R1.

Maximum Power = VI

 $= 10 \times 1340$ = 13400 W

Conclusion based on the above data:

The maximum power of panel-1 with R1 is similar to panel-2 with R2. The maximum power of panel-1 with R2 is similar to panel-2 with R1.

vii Voltage and current of Panel-1 with R1||R2

Time	Voltage(in V)	Current(in mA)
10:00 a.m	7	1368
10:30 a.m	7	1382
11:00 a.m	7	1347
11:30 a.m	6	1095





TERPRETATION:

he preliminary adjustments are done and the connections are given to measure the oltage and current in panel-1 along with R1 parallel to R2. The voltage was found to be 7 and the current was found to be 1368 mA.

Maximum Power = V I
=
$$7 \times 1368$$

= 9576 W

Voltage and current of Panel-1 with R1 series to R2

vili	Von
•	

Time	Voltage(in V)	Current(in mA)
11:30 a .m	16	1060
12:00 p.m	16	1074
12:30 p.m	16	1067
1:00 p.m	16	1058





NTERPRETATION:

The preliminary adjustments are done and the connections are given to measure the voltage and current in panel-1 along with R1 series to R2. The voltage was found to be 16V and the current was found to be 1074 mA.

Maximum Power = V I
=
$$16 \times 1074$$

= 17184 W

	METHODOLOGY OF	GRID SOLAR SYSTEMS
sultage and current	of Panel-2 with R1	R2
ix. Time	Voltage(in V)	Current(in mA)
9:45 a.m	10	1368
10:15 a.m	11	1382
10:45 a.m	11	1347
11:15 a.m	10	1326

Panel-2 & R1 Parallel to R2



NTERPRETATION:

The preliminary adjustments are done and the connections are given to measure the ^{whage} and current in panel-2 along with R1 parallel R2. The voltage was found to be 6 V and the current was found to be 1128 mA.

Maximum Power = V I = 6×1128 = 6768 W

^{This type of connections holds the minimum power. So it is better to avoid these connections in large scale projects. 46}

unge	age and current of Panel-2 with R1 series to R2			
X. Volue	Time	Voltage(in V)	Current(in mA)	
	11:30 a.m	6	1046	
	12:00 p.m	6	1128	
	12:30 p.m	6	1011	
	1:00 p.m	6	1068	

Panel-2 & R1 Series R2



NTERPRETATION:

the preliminary adjustments are done and connections are given to measure the voltage and current in panel-2 along with R1 series to R2. The voltage was found to be 16 V and surrent was found to be 1095 mA.

Maximum Power = V I

METHODAL	Statement of the local division in which the local division in the local division in the local division in the	and the second second	Contraction of the local division of the loc		
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GRID SOLAR SYSTEMS



Time	Voltage(in V)	Current(in mA
8:30 a.m	11	1400
9:00 a .m	14	1795
9:30 a.m	15	1992
10:00 a.m	16	2069



liel to panel-2

with R1

1935.2 1801.4 È 1667.6 1533.8 1400 5 9 T 5 Voltage (∨)

TERPRETATION:

he preliminary adjustments are done and the connections are given to measure the oltage and current of panel-1 parallel to panel-2 along with R1. The voltage was found to e^{16 V} and the current was found to be 2069 mA.

METHODOLOGY OF GRID SOLAR SYSTEMS Introduction of Panel-1 ||Panel-2 with R2 Time Voltage(in V) Current(in mA) 10:00 a.m 16 2055 10:30 a.m 16 2097 11:00 a.m 16 2067 11:30 a.m 16 2104



TERPRETATION:

It preliminary adjustments are done and connections are given to measure the voltage ad current of panel-1 parallel to panel-2 along with R2. The voltage was found to be 16 and current was found to be 2104 mA.

> Maximum Power = V I = 16 x 2104 = 33664 W

^{This type of connections holds the maximum power. So it can be adaptable to large ^{scale products}.}

Time	Voltage(in V)	Current(in mA)
9:45 a.m	10	1312
10:15 a.m	10	1431
10:45 a.m	10	1508
11:15 a.m	10	1408

and current of Panel-1 series to Panel-2 with R1 x^{ii.} Volta





NTERPRETATION:

the preliminary adjustments are done and the connections are given to measure the oltage and current of panel-1 series to panel-2 along with R1. The voltage was found to be 0 V and current was found to be 1508 mA.

Maximum Power = V I
$$= 10 \times 1508$$

= 15080 W

	١	ollage	-
٩.			_

e and current of Panel-1 series to Panel-2 with R2				
Time	Voltage(in V)	Current(in mA)		
11:30 a.m	10	1279		
12:00 p.m	10	1248		
12:30 p.m	10	1228		
1:00 p.m	10	1207		

ries to Panel-2 with R2



1207

TERPRETATION:

the preliminary adjustments are done and the connections are given to measure the tage and current of panel-1 series to panel-2 along with R2. The voltage was found to be W and the current was found to be 1279 mA.

TRPRETATION RESULTS

5. No	Panel	Resistor	Maximum voltage obtained (V)	Maximum current obtained (mA)	M aximum powe r (watt)
1.	Pl	-	20	-	-
2	P2	-	20	-	-
3.	Pl	R1	10	·1340	13,400
4.	Pl	R2	10	1325	13,250
5.	P2	R1	10	1325	13,250
6.	P2	R2	10	1340	13,400
1.	P1	R1 &R2	16	1074	17,184
8.	P1	R1 R2	7	1368	9,576
9.	P2	R1 &R2	16	1095	17,520
0.	P2	R1 R2	6	1128	6,768
1.	P1 P2	RI	16	2069	33,104
2.	P1 P2	R2	16	2104	33,664
.3.	P1&P2	RI	10	1508	15,080
14.	P1&P2	R2	10	1279	12,790

CONCLUSION

- Thus the voltages and current are calculated and their respective graphs are drawn
- From the above tabulation it is found out that when panel-1 and panel-2 are connected in parallel connection along with any resistor R2, the power is maximum.
- The power is minimum when panel-2 is connected to R1 in parallel to R2.
- It is also predicted that the power is high when the temperature is maximum.

CHAPTER-5

FUTURE SOLAR PV TRENDS

This section is designed to highlight the technologies that are driving the solar pV industry, its further development and its potential to significantly impact the energy system. It also explores its challenges as the market growths and

diversifies.

The solar PV industry is changing rapidly, with innovations occurring along the entire value chain. In recent years, a major driver for innovation has been the push for higher efficiency (Green, 2019). This is reflected by the expansion of passivated emitter and rear cell/contact (PERC) technology, which offers more efficient solar cells and as such increases the performance of solar panels. Increasing cell efficiency is key for competitive module manufacturing, as it directly decreases cell processing costs by reducing uantities required for a given output.

fficiency is also very important at the system level, with several factors plaining the push for higher- efficiency technologies. From the technical respective, higher levels of efficiency reduce the number of modules that need be transported to the installation site, the necessary land area and the length of res and cables required. From a marketing perspective, companies able to fer the highest-efficiency modules are also generally perceived as having the shest level of technical expertise.

^{te} next section explores the innovation progress in the solar PV industry in ^{tterials}, module manufacturing, applications, and in ways of decommissioning nels.



MATERIALS AND MODULE MANUFACTURING

The further growth of the solar PV industry largely depends on reducing the palance of system, which makes up most of the total installed system costs and has the greatest potential for cost reduction. Ways of achieving this include sing cheaper cell materials, reducing cell manufacturing costs and increasing ell efficiency levels. The following sections highlight major trends in chnology improvement.

Solar conventional architecture 50¹⁸ ^{(0)^{stalline} silicon (c-Si) panels belong to the first- generation solar PV panels} (1)³¹ and they hold 95% share of worldwide PV production. The economies of scale o main material, silicon, make c-Si more affordable and highly efficient ¹⁰ other materials. Solar panels have improved substantially in terms of their efficiency and power output over the last few decades. The average module efficiency in 2006 was 13.2% for multi crystalline PV panels and 14.7% for mono crystalline PV panels and since then has increased steadily, respectively. This positive trend is expected to continue through 2030. The strong competitive position of c-Si in the market to its continually falling cost has made it difficult for other technologies p compete.

However, despite the high-efficiency level of this first-generation PV chnology, there remains a lot of scope for improvement, including: lowering the cost of c-Si modules for better profit margins, reducing metallic impurities, grain boundaries, and dislocations, mitigating environmental effects by reducing waste and ^{yielding} thinner wafers through improved material properties.

SULCON - ADVANCED SOLAR ARCHITECTURE

PERC cell uses advanced silicon cell architecture. PERC cells are not much different in construction from a typical mono-crystalline PV cell; however, the ^{and} key improvement is the integration of a back-surface passivation layer, which is ^w of material on the back of the cells that is able to improve the cell's efficiency. In fact, the passivation layer increases the overall cell efficiency in three key ways:

it reduces electron recombination Dit increases absorption of light and

i) it enables higher internal reflectivity.

The efficiency gain of implementing PERC architecture for mono-crystalline cells is about 0.8% to 1% absolute, while the boost for multi-crystalline cells sa little lower, at 0.4% to 0.8%.

PERC has started only recently to enter the commercial arena but has quickly become the new industry standard for mono-crystalline cells. Several factors have facilitated this remarkable progress, including the major shift of the market ^{lowards} mono-crystalline cells, the improvement in reliability and throughput of production tools, which has consequently improved the passivation quality of the films, and the real momentum in R&D created by the large number of manufacturers now active in PERC production.

_{Tandem}/hybrid cells

¹¹¹¹¹¹¹¹ solar cells are stacks of individual cells, one on top of the other, that each sekutively convert a specific band of light into electrical energy, leaving the remaining light to be absorbed and converted to electricity in the cell below. Emerging PV technologies comprise several types of tandem cells that can be grouped mainly depending on materials used (e.g. organic, inorganic, hybrid) as well the kind of connection used. The tandem cell approach has been used to fibricate the world's most efficient solar cells that can convert 46% of sunlight into electricity. Unfortunately, these devices use very expensive materials and fabrication processes, and still cannot break through the market.

THIN-FILM

thin film technologies are often referred to as second-generation solar PV. The semiconducting materials used to produce thin-film cells are only a few nicrometers thick (IRENA, 2016). These technologies generally include two main families:

l).silicon-based thin film (amorphous [a-Si] and micro-morph silicon.

^{2).non-silicon} based (perovskites, cadmium telluride [CdTe] and copper-indium-^{gallium-} diselenide [CIGS]). These technologies can be cheaper to produce, as such they are being deployed on a commercial scale, but they have historically had lower efficiency levels.

technology for large-scale power generation gained prominence thin 2006, when the cost of silicon rose due to increased demand. Thin-film therefore, made more economic sense despite their low efficiency. μ_{0} by 2012 the falling silicon prices, combined with the falling price of μ_{0} we ver, by 2012 the falling price of efficient c-Si modules, have shifted production towards c-Si technology. whilst first-generation crystalline silicon-based PV has therefore consolidated its commercial status following performance improvements and cost reductions in recent years, the overall market share of thin-film technologies has been constantly decreasing since 2012. Currently, thin-film technology accounts for only 5% of the global solar PV market, while silicon-based solar modules still hold approximately 95% of the global PV module market.

Non-silicon based thin-film technologies

Perovskites

Currently most solar cells are made from silicon; however, an area to watch is be development of new materials for solar cells. In particular, one of the most mmising material is perovskites, a type of mineral very good at absorbing ight. The first perovskite PV devices in 2009 converted just 3.8% of the energy ontained in sunlight into electricity. However, because crystals are very easy to make in the lab, their performance was quickly improved and by 2018 their fficiency had soared to 24.2%, set by researchers in the United States and the Republic of Korea close to silicon's lab record of 26.7%. However, perovskite efficiency records have only been set on tiny samples.

herniskites still face some significant challenges before achieving market one of the main ones is durability. Because the crystals dissolve easily. More not able to handle humid conditions and need to be protected by moisture are not able to handle humid conditions and need to be protected by moisture through encapsulation, for instance through an aluminium oxide layer or sealed plass plates. Another challenge for scientists is that, whist they have been able to achieve high efficiency levels with small perovskites, they have not been able preplicate such effect with larger cell areas.

If these barriers can be overcome, perovskites cells have the potential to change the dynamics and economics of solar power because they are cheaper to produce than solar cells and can be produced at relatively low temperatures, unlike silicon.

Copper indium gallium selenide cells (CIGS)

CIGS cells have achieved high efficiency levels comparable to commercial systalline silicon. However, manufacturing CIGS cells can be difficult due to the unity of indium, as well as to the complex stoichiometry and multiple phases to moduce them, restricting large-scale production in the near term.

admium telluride (CdTe)

^{admium} telluride cells have achieved an efficiency of 21%, very similar to ^{IGS}, and are characterized by good absorption and low energy losses. CdTe solar ^{IIs} are made through low- temperature processes, which makes their ^{Iduction} very flexible and affordable. CdTe currently has the largest market ^{Ite of all} thin-film technologies.

ADVANCED MODULE TECHNOLOGIES

The emergence of new cell architectures has enabled higher efficiency levels. A major driver of this shift has been the emergence of the PERC cells and their compatibility with other emerging innovations, such as half-cut cells. Looking ahead, the most important technological shift in the market relates to bifacial cells and modules, driven by the increased adoption of advanced cell architecture and a focus on system output levels.

Bifacial solar cells

Bifacial solar cells have been under development for decades and their manufacturing process can be considered one of the most advanced for solar modules today. Bifacial cells are capable of generating electricity not only from sunlight received on their front, but also from reflected sunlight received on the reverse side of the cell. At the time of writing China retains its status as the argest manufacturer of, and end market for, bifacial modules. Worldwide demand has also increased, with countries such as the United States, Brazil and the United Kingdom increasing their use of bifacial modules for utility-scale PV plants. Based on the current market trend, bi-facials are extending their geographical ltach from Europe and Japan to emerging markets and across the globe.

^{Bifacial} operation, facilitated by the uptake of PERC, offers a near- term ^{effective} efficiency increase of 5–20% relative by increasing the energy output from a given module area. According to the Fraunhofer ISE's module technology

NPV ANCED MODULE TECHNOLOGIES

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nearly every cell producer that has upgraded to PERC is also working on technology, and the greater that PERC expands, the greater that bifacial will too. Despite the growth and advantages of bifacial cells, the mology still has some obstacles to overcome, such as the lack of an emology still has standard, no common ground for power labeling or pricing, will simulation and bankability issues.

the of bifacial module is the glass-glass module. These are solar panels with cells arranged between two glass panes. They are typically applied to utilityesystems and provide a heavy-duty solution for harsh environments (*e.g.* high pertures, high humidity) because they are less sensitive to penetration of meture. The technology has already been under development for decades, but high costs and heavy weight has been a barrier to their development. cording to the International Technology Roadmap for Photovoltaic (ITRPV), in the share of glass-glass modules was only 5% and is expected to just double 2020. However, despite the limited growth foreseen in the short term, the RPV expects the technology to pick up within the next 10 years and reach a Ashare.

^a PV module, solar cells are electrically connected to strings. This ^{trconnection}, however, can cause optical losses in the module, which affects ^treliability of the product. To overcome this limitation, various industrial ^{tinging} equipment and soldering technologies are being developed, such as ^{alf-cells}, solar shingles and multi-bus bars.

ficells involve deliberately cutting a fully processed cell into half with very have machines. Half- cells are being adopted quickly, thanks to the that from a manufacturing point of view only minor changes are needed to uble laser machines. Half- cells improve module performance and durability, can provide an instant power boost of 5-6 watts.

hib-bus bars

solar cells are metalized with thin strips printed on the front and rear of a cell; these are called bus bars and have the purpose of conducting the electric set current (DC) power generated by the cell. Older solar cells typically had obus bars; however, the industry has moved towards higher efficiencies and bars have increased to three (or more) in most solar cells. The increased mber of bus bars has several advantages: first is the high potential for cost ing due to a reduction in metal consumption for front-facing metallization and, series resistance losses are reduced by employing thin wires instead of war ribbon and third, optimizing the width of the bus bars leads to an ditional rise in efficiency. A higher number of bus bars leads to higher module liciencies because of reduced internal resistance losses; this is due to the lower Mance between the bus bars. Finally, multi-bus bar design is highly beneficial bifacial technology, especially for improving the bi-facility for PERC cells f 90%.

	LEVEL OF MATURITY AND PROSPECTS
Halffut	According to the ITRPV, a significant uptick is foreseen in the near future – from less than 3% market share in 2017 to 5% in 2018 and 10% by 2020.
Shingles	Although several companies are displaying prototype shingle modules, the Fraunhofer ISE believes that the technology is not yet mature enough, especially due to the fact the manufacturing machinery is not completely optimized.
Bifacial	From almost negligible presence in 2017, the ITRPV anticipates the bifacial concept to gain close to 10% market share in 2018, 15% in 2020 and 40% within the next 10 years.
Glass-glass modules	Despite the small growth foreseen in the short term, the ITRPV expects the technology to pick-up within the next 10 years and reach a 40% share.
ulti-bus bars	The ITRPV expects the three-bus bar layout to be phased out progressively and be replaced by layouts with 4, 5, 6 and more bus bars.

solar shingles

solar shingles are a type of solar energy solution where solar panels are designed to we like conventional roofing materials, while also producing electricity. Solar shingles have several advantages. First, a key advantage is that they eliminate the peed for ribbon, connecting cells like roof tiles. Second and related to the removal of the ribbon, module aesthetics are improved, as the panels are homogeneously colored.

Third, unlike a standard cell, cells for shingle modules have bus bars at opposite ends and cells are sliced into several strips, which reduces the current and consequently the load on fingers. This also enables a reduction in the number of fngers as well as their thickness, which decreases shading and improve output power of the cell.

APPLICATIONS: BEYOND FIELDS AND ROOFTOP

Taking advantage of the rapidly growing solar PV capacity across the globe, several research projects or prototypes are underway to stimulate future market growth, exploring innovating solar technologies at the application level. The major developments are as follows.

SOLAR TREES

solar trees work very much like real ones, as they have leaf-like solar panels connected through metal branches using sunlight to make energy. Solar trees can be seen as complementary to rooftop solar systems. They are more ergonomic than solar panels, taking nearly 100 times less space to produce the same amount of electricity as a horizontal solar plant and, as such, constitute a solution for land- and space- scarce economies.

SOLAR-POWERED DESALINATION

Most desalination plants today are powered by fossil fuels, which makes them unsustainable in the long term. The two techniques mostly used by the desalination industry to produce potable water are membrane-based and thermal. Because membrane-based desalination techniques do not require heat, they can be coupled with wind and solar power generation. With the fall in the cost of PV equipment and the increasing demand for desalination, more PV-powered membrane desalination plants can be expected in the coming years.

NAR CARPORTS

scarports are ground-mounted solar panels that are installed so that parking lots thome driveways can be laid underneath to form a carport. They have been a popular alternative or supplement to the classic rooftop systems, with the antage that they can be installed entirely independently of the roof angle, shape orientation of the house. Besides providing shade to the vehicles parked demeath, they can efficiently produce electricity and thus offer a number of nefits. First, if coupled with a well- designed charging system, the electricity duced can be used for EV charging and thus reduce the costs of running the hicle. Second, they can provide energy storage enhancements by having battery rage integrated and available in the system, making the solution independent of shine hours. Third, unlike ground-level systems, they are easy to customize and save space as they do not require an additional structure or land to install them

he installation of solar carports is increasing steadily and several factors are aving the growth. Cost is indeed an important factor, as the application is oving out of the niche and into the mainstream, and EV adoption is playing a votal role. The price difference between rooftop PV and solar carports ontinues to narrow, and they are becoming a strong and attractive economic roposition in a growing number of markets. Increased commercial-scale opplication is also driven by utilities, which are embracing distributed eneration as a way to improve grid reliability.

_{50LAR} PV-THERMAL SYSTEMS

solar PV-T systems combine the production of both kinds of solar energy in one collector. It consists of a solar PV panel combined with a cooling system where cooling agent is circulated around the PV panels to cool the solar cells, such that the warm water or air leaving the panels may be used for domestic applications such as domestic heating. This cooling system for PV panels has a motiold benefit: it significantly increases the efficiency of PV systems in the electricity sector, and it also allows for the capture of the heat from the PV system for use in space, water and process heating in a range of industries and applications.

AGROPHOTOVOLTAIC

Agrophotovoltaic (APV) combines solar PV and agriculture on the same land and consists of growing crops beneath ground-mounted solar panels. Although the concept was proposed long ago, it has received little attention until recently, when several researchers have confirmed the benefits of growing crops beneath the shade provided by the solar panels. These include higher electricity production, higher crop yields and less water used (Beck, M. et al., 2019). APV is a win-win situation for both crops and the solar panels. Many types of food props, such as tomatoes, grow better in the shade of solar panels, as they are pared from the direct sun and experience less water loss via transpiration, which also reduces water use while maintaining the same level of food.



the project "Agro-photovoltaics Resource-Efficient Land Use has tested the $_{\rm APV}^{\rm concept}$, showing a land use efficiency of 160% in 2017 and 186% in and thus confirming earlier research results. The project is located in germany, near Lake Constance, and consists of a 194 kW solar system on a 5 meter high structure above land used to grow celery, clover, potatoes and wheat. The project results show that in 2018 land use efficiency mereased, with yields from three of the four crops grown under the panels achieving above the reference yield thanks to the shade under the solar nodules, which helped them to better resist the dry conditions in 2018. In act, solar irradiation beneath the PV system was approximately 30% less han the reference field, the soil temperature was lower even if the air emperature remained the same and the soil moisture was kept higher than e reference field in summer and lower in winter months. The project onfirmed the applicability of APV in arid regions, especially in eveloping countries; it also calls for the exploration of APV's applicability nder other climate conditions and with other types of crops.

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SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES

Project work submitted to St. Mary's College (Autonomous), Thoothukudi, affiliated to Manonmaniam Sundaranar University, Tirunelveli in partial fulfilment of requirements for an award of,

BACHELOR'S DEGREE IN PHYSICS

BY

A. Jerisha - 19AUPH15

S. Kamaladevi - 19AUPH18

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DR. SR. JESSIE FERNANDO



DEPARTMENT OF PHYSICS

St. Mary's College (Autonomous), Thoothukudi-1

(Re-Accredited with "A+" grade)

2021-2022
CERTIFICATE

This is to certify that this project work entitled, "SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES" is submitted to ST. MARY'S COLLEGE (AUTONOMOUS), THOOTHUKUDI in partial fulfilment for the award of Bachelor's Degree in Physics and is a record work done during the year 2021-2022 by the following students.

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5/22

EXAMINER

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GUIDE

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EXAMINER

PRINCIPAL

DECLARATION

We hereby declare that the project entitled, " **SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES** " submitted to St. Mary's College (Autonomous), Thoothukudi, affiliated to Manonmaniam Sundaranar University, for the Bachelor's Degree of Science in Physics is our original work and that, it has not previously formed the basis for the award of any Degree, Diploma or similar title.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION:

Nanotechnology is booming due to the emergence of nanomaterials (especially inorganic nanoparticles (NPs) and nanorods) with unique functions and sizedependent 2on-me-chemical properties, which are different from each other. Significantly different from bulk materials [1]. The potential of inorganic NPs has been explored worldwide in nanomedicine, drug delivery and biomedical devices, cosmetics, electronics, energy field and environmental protection [2–4]. Among inorganic NPs, silver nanoparticles (AgNPs or nanosilver), due to their novel chemical, physical and biological properties compared with their bulk form, have attracted the attention of researchers from various academic laboratories [5]. AgNPs have exceptional physical and chemical properties, for example, high thermal and electrical conductivity, surface-enhanced Raman scattering, chemical stability, catalytic activity, and nonlinear optical behaviour [6]. These attributes place AgNPs at the top of the priority list for use in printing inks, electronics and for medical purposes [7]

Recently, the number of publications on the topic of AgNPs has increased rapidly and the number of articles published has increased by 93% since 2001-2011. During this period, in 2001 there were 247 articles published, in 2011 it increased to 3603 articles. Most of them have been published in the fields of chemistry, materials science [8], physics, engineering, polymer science, spectroscopy, electrochemistry, molecular biochemistry, optics and spectroscopy [9].

1.2 SCOPE OF NANOSCIENCE AND TECHNOLOGY:

The prefix "nano" refers to a Greek prefix that means "dwarf" or something very small and represents one thousandth of a millionth of a meter (10^{-9} m) . It is

important to distinguish between nanoscience and nanotechnology. Nanoscience is the study of structures and molecules at the nanometer scale from 1 to 100 nm and the technology to use it in practical applications like devices etc, called nanotechnology [10]. For comparison, realize that a human hair is 60,000 nm thick and the DNA double helix has a radius of 1 nm [11]. Nanotechnology is the ability to transform nanoscience theory into useful applications by observing, measuring, manipulating, assembling, controlling, and fabricating matter at the nanometer scale.



Fig 1.1 Scope of Nanoscience and Technology

1.3 NANOSCALE:

Nanoscale usually refers to length-scale structures applicable to nanotechnology, usually reported to be 1-100 nanometers. Nanometers are one billionth of a meter. Nanoscale is the lower limit of most solid mesoscopic scales. It is not possible to clearly and quickly define what the nanoscale is, but there are some very important things. It is small in size and has different characteristics



Fig 1.2 Shape of Nanoparticle

1.4 TYPES OF NANOPARTICLES:

Organic and inorganic nanoparticles are the two basic types of nanoparticles. Micelles, dendrimers, liposomes, hybrid and compact polymeric nanoparticles fall within the first category. Fullerenes, quantum dots, silica, and metal nanoparticles make up the second group. The appearance, size, and chemical properties of nanoparticles are also used to classify them. Some of the most important classes of nanoparticles are based on physical and chemical characteristics:

• **Carbon-based materials** – (fullerenes, carbon nanotubes, graphene, carbon dots). Electrical conductivity, high strength, structure, electron affinity, and adaptability are all attractive features of these materials.

• **Metal** – They are constructed entirely of metal predecessors. These have unusual optoelectrical qualities due to well-known localised surface Plasmon resonance (LSPR) features.

• **Ceramics** – Researchers are paying close attention to these inorganic non-metallic solids because of their unique properties.

• Semiconductor – Semiconductor materials have qualities that are intermediate between metals and 4on-metals, as well as large band gaps. Their

qualities are significantly altered as a result of band gap tuning. As a result, they're crucial in photo catalysis, photo optics, and electronic devices.

• **Polymers** – For a wide range of applications, including surface coating, sensor technology, catalysis, and nanomedicine, scientists have devised a number of ways for synthesising polymeric nanoparticles.

• **Lipids** – These NPs include lipid moieties and are used as medication carriers in a variety of biological applications (the mRNA Covid-19 vaccines are using lipid nanotechnology). Lipid nanoparticles are also thought to be a viable delivery mechanism for nucleic acids in gene therapy.

1.5 DIMENSIONALITY AND CLASSIFICATION OF NANOPARTICLES:

Dimensionality, shape, composition, homogeneity, and aggregation are all used to classify nanoparticles.

• Zero-dimensional nanomaterials

OD are nanosized particles that have their length and width within the nanometer range, they are simply nanoparticles.

• One-dimensional nanomaterials

The circuitry of computer chips and the antireflection and hard coatings on eyeglasses are examples of one-dimensional thin films or surface coatings on the nanoscale scale. Electronics, chemistry, and engineering have all employed them.

• Two-dimensional nanomaterials

Nanomaterials with two dimensions have two dimensions on the nanoscale scale. Nanopore filters for tiny particle separation and filtration are examples of 2D

nanostructured films with nanostructures securely linked to a substrate. 2D nanoparticles, such as asbestos fibres, are an example.

• Three-dimensional nanomaterials

3D nanomaterials are materials that are nanoscaled in all three dimensions. Thin films deposited under conditions resulting in atomic-scale porosity, colloids, and free nanoparticles of diverse morphologies are among them



Fig 1.3 Dimension of Nanoparticles

1.6 REVIEW OF LITERATURE:

L. Balan et al. (2010) proposed extending the concept of photochemically assisted synthesis of metal nanoparticles by direct reduction of metal ions or complexes to the NIR range, a spectral region of critical interest for in situ implementation of integrated optical functions but where photochemical activation is often critical due to the weak electronic energy carried by photons. The transient species employed to decrease silver cations were used to initiate a photopolymerizable formulation. It was discovered that when NIR light is activated at 300 mW/cm², metal nanoparticles are homogeneously disseminated in the appropriate polymer material, resulting in a metal/polymer nanocomposite. The structure of the poly-methine sensitizers has specific properties that strongly suggest the participation of their triplet state. This achievement could open up new avenues in numerous domains of research, where in situ photochemical production of MNPs induced by NIR should help overcome technical barriers [12].

V. K. Sharma, R. A. Yngard, and Y. Lin et al., (2008) The electrical, optical, and catalytic characteristics of silver integrated into polymer and TiO2 surfaces are favourable. Different surface modification synthetic techniques were shown, resulting in various particle morphologies. To make progress in particle interactions, approaches to detect Ag NP transport in vivo on real-time scales are required. This will also disclose how Ag NPs affect critical aquatic species and their environmental effects. As the usage of Ag NPs in consumer products grows, more of these particles will be released into the environment, necessitating a study of the environmental concerns connected with these particles. An analytical approach that can identify nano-Ag metal from dissolved Ag+ species under environmental circumstances is required for ecotoxic investigations on the exposure of Ag NPs. Although such approaches are becoming more widely available, their use at low doses is still limited [13].

D. Kim, S. Jeong, and J. Moon et al., (2006) Thepolyol technique was used to create spherical silver nanoparticles of various diameters and standard deviations. The influence of reaction parameters on the final particle size and dispersion was investigated using two distinct synthesis methods. The ramping rate was shown to be a crucial element determining particle size in the precursor heating approach, which involved heating a solution containing silver nitrate to the reaction

temperature. Because of quick nucleation, the injection rate and reaction temperature were critical factors in lowering particle size and achieving monodispersity in the precursor injection method, in which a silver nitrate aqueous solution was injected into hot ethylene glycol. At a rate of 2.5mls-1 and a reaction temperature of 100 °C, silver nanoparticles with a diameter of 172nm were produced. [14]

J. Yu and X. Zhou et al., (2013), Silver nanoparticles are made via electro deposition in an electrolyte with a low Ag+ content and a high overpotential. The as-prepared dendritic Ag nanoparticles have good SERS characteristics and can be employed as a suitable substrate for Rhodamine 6G detection in practical SERS applications [15].

1.7 OBJECTIVE OF THE PRESENT WORK:

The objective of the present work is:

- To synthesis Ag Nanoparticles
- To determine the structure and size of the pure Ag nanoparticles using X –Ray Diffraction analysis, SEM and EDAX.

1.8 SIGNIFICANCE OF SILVER MATERIAL:

1.8.1 SILVER:

Silver nanoparticles are appealing due to their unique properties (e.g., size and shape-dependent optical, electrical, and magnetic properties) that can be used in antimicrobial applications, biosensor materials, composite fibres, cryogenic superconducting materials, cosmetics, and electronic components. Silver nanoparticles have been synthesised and stabilised using a variety of physical and

chemical methods [16, 17]. The most common chemical processes for the manufacture of silver nanoparticles are chemical reduction utilising a variety of organic and inorganic reducing agents, electrochemical techniques, physicochemical reduction, and radiolysis. Nanoparticle synthesis has recently become one of the most fascinating scientific fields, with a growing interest in producing nanoparticles using environmentally benign ways (green chemistry). Mixed-valence polyoxometalates, polysaccharides, Tollens, biological, and irradiation processes are examples of green synthesis approaches that have advantages over traditional methods that use chemical agents that are detrimental to the environment.

1.8.2 COMMON USAGE:

Ag-NPs are widely employed in everyday commercial items such plastics, food packaging, soaps, pastes, food, and textiles, resulting in a significant increase in their market value [18]. Ag-NPs are important because they can be found in a variety of forms, including colloidal (enamel, coatings, and paints), liquid (shampoo), solid (blending Ag-NPs with a solid material such as polymer scaffolds), and even suspended in materials like soap and nonwoven fabrics. Even in the textile sector, where Ag-NPs are used in water filtering membranes [18, 19], their value cannot be overlooked.

1.8.3 APPLICATIONS OF Ag-NPs IN NANOFIELD:

• Nanomaterials can exist naturally, be formed as by-products of combustion reactions, or be engineered specifically to fulfil a certain function.

• Nanomaterials are used in a wide range of industries, from healthcare and cosmetics to environmental preservation and air purification, due to their capacity to create materials in a specific way to perform a specified function.

• Carbon nanotubes can be utilised to morph aeroplane wings in aerospace. The nanotubes are combined in a composite form that bends when an electric voltage is applied.

• Baseball bats produced with carbon nanotubes are lighter and perform better, according to the sports industry. Antimicrobial nanotechnology, which is employed in things such as towels and mats used by athletes, is another example of nanoparticles in this business.

• Silver nanoparticles possess many valuable optical properties that have opened the door to new approaches in sensing and imaging applications, providing a wide range of detection modes such as colorimetric, dispersion techniques radiation, SERS and MEF, at extremely low detection limits. In addition, nanoparticles have made it possible to use diffusion imaging techniques and have brought valuable improvements to standard imaging techniques.

• Military applications for nanomaterials have also been developed. One example is the injection of movable pigment nanoparticles into the material of soldiers' uniforms to provide a better kind of camouflage. The military has also created sensor devices that can identify biological agents using nanomaterials such as titanium dioxide.

• Nano-titanium dioxide is also used in coatings to create self-cleaning surfaces like those found on plastic garden chairs. The coating is coated with a sealed film of water, and any dirt dissolves in the film, which is then removed by the following shower, thus cleaning the seats.

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• Engineers may design photovoltaics (PV) and solar thermal devices with customised solar absorption rates by controlling the size, shape, and substance of the nanoparticle. Solar radiation absorption is substantially higher in nanoparticle-based materials than in thin films of continuous sheets of material.

• The Sol-Gel technique is a way to make solid material out of nanoparticles. While it is considered a relatively recent industrial technology, it is widely employed in a variety of industries, including abrasive powder manufacturing, coatings manufacturing, and optical fiber manufacturing.

1.8.4 BIOLOGICAL APPLICATIONS OF Ag-NPs:

• Antibacterial Activity of AgNPs :

• AgNPs appear to be an alternative to antibiotics in terms of antibacterial activity and the capacity to overcome antibiotic resistance in bacteria. As a result, AgNPs must be developed as antibacterial agents.

• Due to their huge surface-to-volume ratios and crystallographic surface structure, AgNPs appear to be viable antibacterial agents among the many promising nanomaterials.

• The seminal paper reported by Sondi and Salopek-Sondi[20] demonstrated the antimicrobial activity of AgNPs against Escherichia coli, in which E. coli cells treated with AgNPs showed the accumulation of AgNPs in the cell wall and the formation of "pits" in the bacterial cell wall, eventually leading to cell death.

• Antifungal Activity of AgNPs :

• Fungal infections are more common in immunocompromised patients, and conquering fungi-mediated disorders is a time-consuming process due to the restricted number of antifungal medications now accessible [21].

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• As a result, there is an unavoidable and pressing need to produce biocompatible, non-toxic, and environmentally acceptable antifungal agents

• At this point, AgNPs serve a significant function as anti-fungal agents against a variety of fungal infections.

• At doses of 1–7 g/mL, Nano-Ag showed strong antifungal activity against clinical isolates and ATCC strains of Trichophytonmentagrophytes and Candida species.

• Antiviral Activity of AgNPs:

• Viral mediated diseases are frequent and becoming more prominent in the world; consequently, creating anti-viral medications is crucial.

• The mechanisms of the antiviral activity of AgNPs are an important aspect in antiviral therapy.

• AgNPs interact with bacteria and viruses differently depending on their size and form [22, 23, 24].

• The antiviral activity of nano-Ag integrated into polysulfide ultrafiltration membranes (nAg-PSf) was tested against MS2 bacteriophage, revealing that improved membrane hydrophilicity resulted in considerable antiviral activity [25].

• Anti-Antigenic Activity of AgNPs:

• Cancer and numerous ischemia and inflammatory disorders are associated with pathological angiogenesis [26].

• Several research organisations are working on developing innovative pro- and anti-angiogenic chemicals to combat angiogenic illnesses.

• Although several synthetic molecules with anti-angiogenic properties have been discovered, the discovery of a series of natural pro- and anti-

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angiogenic factors suggests that in the near future, this may provide a more physiological approach to treating both classes of angiogenesis-dependent diseases [27].

1.9 IMAGE OF SILVER NANOPARTICLE :



Fig 1.4 Silver Nanoparticle

CHAPTER 2

PREPARATION OF PURE SILVER NANOPARTICLE

PREPARATION OF PURE SILVER NANOPARTICLE

2.1 INTRODUCTION:

There are few methods to synthesis nanoparticles. Slow evaporation, hydro thermal, co-precipitation, sol-gel process are some of them.

2.2 CHEMICAL APPROACH:

The chemical, physical, optical, and electrical characteristics of nanomaterials are influenced by their size, shape, and surface morphology. Chemical reduction is one of the most frequent ways for producing silver nanoparticles using both inorganic and organic reducing agents. For the reduction of silver ions (Ag+) in aqueous or nonaqueous solutions, various reducing agents such as sodium citrate, ascorbate, sodium borohydride (NaBH4), elemental hydrogen, polyol process, Tollens reagent, N, N-dimethylformamide (DMF), and poly (ethylene glycol)-block copolymers, hydrazine, and ammonium formate are used.

2.3 CO-PRECIPITATION METHOD:

The simultaneous precipitation of a normally soluble component with a macro-component from the same solution by the formation of mixed crystals, by adsorption, occlusion or mechanical entrapment. Coprecipitation is a kind of precipitation where soluble compounds in a solution are eliminated during the course of precipitation. Precipitation is a process in which a solid is precipitated from a solution containing other ions. These ions are incorporated into the solid by adsorption on the surface of the growing particles, physical trapping in the porous space, or substitution in the crystal lattice. Adsorption is one of the main co-precipitation mechanisms. It is a process in which a solid, or adsorbent, is added to

a solution containing other ions, known as an adsorbent. In this case, the adsorbents are bound to the surface of the solid by physical or chemical interactions between the adsorbent and the adsorbent.

Co-precipitation helps to hold the required cations close together in the reaction medium and lowers the temperature of decomposition, just as in the case of the sol– gel process. The starting materials can be simple metal salts that can easily be dissolved in water or other appropriate solvents.

2.3.1 TYPICAL CO-PRECIPITATION SYNTHESIS METHOD:

Metals generated from aqueous solutions, reduction from non-aqueous solutions, electrochemical reduction, and breakdown of metal organic precursors are examples of typical co-precipitation synthesis methods. Metal chalconides are generated through reactions of molecular precursors. Oxides are created from aqueous and non-aqueous solutions. Coprecipitation with microwave sonication.

2.3.2 ADVANTAGES:

Through different chemical reactions in the solution, the co precipitation technique has the advantage of directly generating homogenous nanomaterials with tiny size and size dispersion.

- Easy and quick to prepare.
- Particle size and composition may be easily controlled.
- A variety of ways to alter particle surface state and overall homogeneity
- It's cold outside.
- It saves energy.
- Doesn't need the use of an organic solvent.

2.3.3 DISADVANTAGES:

- Uncharged species are not included.
- Trace contaminants in the product may also precipitate.
- It takes time.
- Issues with batch-to-batch repeatability.

• When the reactants have highly differing precipitation rates, this approach fails [28].

2.4 MATERIAL PREPARATION:

In the present work, pure silver nanoparticles are prepared by reduction method. This method is simplest and convenient pathway to synthesize nanoparticles.

2.4.1 SYNTHESIS OF PURE SILVER NANOPARTICLES:

First the beaker is washed thoroughly with ethanol. 20g of Poly Ethylene Glycol is dissolved in 1litre of distilled water. The mixture is poured in to a beaker and kept on a magnetic stirrer and stirred thoroughly for 1hour without setting temperature. Further stirred for ¹/₂ an hour at 60° C and cooled. 10g of (AgNO₃) Silver Nitrate is added and stirred for 1¹/₂ an hour without setting temperature. The NaOH solution is added until pH value reaches approximately 10.The pH value is constantly noted to maintain the required pH in the solution using the pH meter. Now the color of the solution changes to brownish yellow color. The sample is filtered and heated in hot air oven at 100° C. The dried sample is placed in muffle furnace at 700° C. The precipitate thus obtained is finely powered. Thus the Silver nanoparticles are obtained. The following equipments in the lab were used,

- Muffle furnace
- pH meter
- Hot air oven

2.4.2 MUFFLE FURNACE:

The beaker is first carefully cleaned with ethanol. A Muffle furnace is a jacketed enclosure used to heat a material to extremely high temperatures while keeping it enclosed and completely protected from extraneous pollutants, chemicals, or substances. Muffle furnaces are often lined with stainless steel, making them resistant to corrosion. Muffle furnaces were created to mitigate the negative effects of combustion-based heating. Unwanted byproducts such as ash, soot, and gas emissions are examples of such results. Muffle furnaces can achieve and maintain temperatures of up to 1800°C (3270°F).



Fig 2.1 Muffle furnace

2.4.3 pH METER:

A pH meter is a scientific tool that determines the acidity or alkalinity of waterbased solutions by measuring hydrogen-ion activity. The pH meter is frequently referred to as a "potentiometric pH meter" because it detects the difference in electrical potential between a pH electrode and a reference electrode. The acidity or pH of the solution is related to the difference in electrical potential.



Fig 2.2 pH meter

2.4.4 HOT AIR OVEN:

Hot air ovens are electrical sterilisation equipment that employ dry heat. The temperature is usually controlled using a thermostat. Because the inner layer is a poor conductor and the outer layer is metallic, their double walled insulation retains the heat in and conserves energy. In addition, there is an air-filled area between them to help with insulation. An air circulating fan aids in heat distribution uniformity. These come with adjustable wire mesh plated trays or aluminium trays, as well as an on/off rocker switch, temperature and holding time indicators and controls.



Fig 2.3 Hot air oven

















Fig 2.1 Synthesis of Silver Nanoparticle

2.5 FLOW CHART:



CHAPTER 3

CHARACTERIZATION OF NANOPARTICLES

CHARACTERIZATION OF NANOPARTICLES

3.1 INTRODUCTION:

AgNP characterization is crucial for assessing the functional properties of the particles formed. Among the analytical techniques used for characterization include UV-vis spectroscopy, X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM). Several qualified books and reviews have provided the concepts and use of various types of analytical techniques for the characterisation of AgNPs; The physicochemical properties of nanoparticles regulate their behaviour, safety, and efficacy. As a however, the basics of the most essential approaches utilised for the characterization of AgNPs are detailed below for ease understanding.

3.2 UV-VISIBLE SPECTROSCOPY:

UV-Visible Spectroscopy is based on chemical compounds absorption of ultraviolet or visible light, which results in the formation of different spectra. The interaction of light and matter is the basis of spectroscopy. Excitation and deexcitation occur as matter absorbs light, resulting in the formation of a spectrum.



Fig 3.1 UV-Visible spectroscopy

When matter absorbs ultraviolet light, the electrons within it become excited. This leads them to transition from a ground state (an energy state with a low quantity of energy) to an excited state (an energy state with a relatively large amount of energy associated with it). It's worth noting that the difference between the energies of the electron's ground and excited states is always equal to the quantity of ultraviolet or visible energy it absorbs.

The most significant disadvantage of using a UV-VIS spectrometer is the amount of time it takes to prepare for usage. When employing UV-VIS spectrometers, proper setup is essential. Outside light, electrical noise, and other impurities that could interfere with the spectrometer's reading must be removed.

3.3 X-RAY DIFFRACTION (XRD):

X-ray powder diffraction (XRD) is a quick analytical technique that can offer information on unit cell dimensions and is mostly used for phase identification of crystalline materials. The studied material is finely powdered, homogenised, and the bulk composition is calculated on an average basis.



Fig 3.2 X-ray powder diffraction (XRD)

In 1912, Max von Laue observed that crystalline substances act as threedimensional diffraction gratings for X-ray wavelengths that are similar to plane spacing in a crystal lattice. The technique of X-ray diffraction is currently widely used to analyse crystal structures and atomic spacing.

Constructive interference between monochromatic X-rays and a crystalline sample is the basis of X-ray diffraction. A cathode ray tube produces the X-rays, which are then filtered to produce monochromatic radiation, collimated to concentrate the beam, and aimed onto the sample. When Bragg's Law (n=2d sin θ) is satisfied, the incident rays interact with the sample to create constructive interference (and a diffracted ray). The wavelength of electromagnetic radiation is related to the diffraction angle and lattice spacing in a crystalline sample by this rule. After that, the diffracted X-rays are detected, processed, and tallied. Due to the random orientation of the powdered material, scanning the sample across a range of 2 angles should provide all potential lattice diffraction directions. Because each mineral has its own set of d-spacings, converting the diffraction peaks to d-spacings enables for mineral identification. This is usually accomplished by comparing d-spacings to established reference patterns.

3.4 ENERGY DISPERSIVE X-RAY ANALYSIS (EDAX):

Energy Dispersive X-Ray Analysis (EDX), referred to as EDS or EDAX, is an x-ray technique used to identify the elemental composition of materials. Energy dispersive X-ray Analysis (EDX) is an analytical method for analytical or chemical characterization of materials. EDX systems are generally attached to an electron microscopy instrument such as transmission electron microscopy (TEM) or scanning electron microscopy (SEM). EDX is based on the emission of a specimen

characteristic X-rays. A beam of high energy charged particles (electrons or protons) are focused into the investigated sample. An electron from a higher binding energy electron level falls into the core hole and an X-ray with the energy of the difference of the electron level binding energies is emitted. EDX analysis gives a spectrum that displays the peaks correlated to the elemental composition of the investigated sample. In addition, the elemental mapping of a sample can be created with this characterization method.



Fig 3.3 Energy Dispersive X-Ray Analysis (EDX)

3.5 SCANNING ELECTRON MICROSCOPY:

Scanning electron microscopes (SEMs) have grown in power and versatility as the size of materials utilized in diverse applications has shrunk in recent years.

In the same manner as light microscopes employ visible light for imaging, electron microscopes use electrons. Unlike transmission electron microscopes (TEMs), which detect electrons passing through a very thin specimen, SEMs make images by using electrons reflected or knocked off a sample's near-surface area. Because electrons have a shorter wavelength than light, their resolution is superior than that of a light microscope.

The electron beam scans the material in a raster pattern in scanning electron microscopy. The electron source first generates electrons at the top of the column. These are released when their thermal energy exceeds the source material's work function. The positively charged anode then accelerates and attracts them. The whole electron column must be vacuum-sealed. The electron source, like all other components of an electron microscope, is sealed inside a specific chamber to maintain vacuum and protect it from contamination, vibrations, and noise. Vacuum not only protects the electron source from contamination, but it also allows the user to obtain a high-resolution image. Other atoms and molecules may be present in the column if there is no vacuum. The electron beam deflects as a result of their contact with electrons, lowering image quality. High vacuum also improves the efficiency of electron collection by the detectors in the column.



Fig 3.4 Scanning electron microscopes (SEMs)
CHAPTER 4

RESULT AND DISCUSSION

RESULT AND DISCUSSION

4.1 CHARACTERISATION USING XRD:

The structural characterization of the pure silver oxide nanoparticle is carried out by XRD method. From the above observations it is clearly indicates that the silver oxide nanoparticles exhibit FCC structure as confirmed from the JCPDS File No.: 03-0921.

The average grain size can be estimated by applying the Scherrer's equation:

$$\mathbf{D} = \frac{\kappa\lambda}{\beta\cos\theta} \quad \longrightarrow \quad (1)$$

Where,

- D is the gain size or particle size (nm)
- β is the full width at half maximum (FWHM) of a broad diffraction peak
 - λ is the X-ray wavelength (1.5406 Å)
 - θ is the Bragg's angle (degree)
 - K is the Scherrer constant (0.9)

Figure (4.1) shows that the X ray diffraction pattern of Silver oxide nanoparticles. The X-ray diffraction pattern of Ag₂O nanoparticles shows sharp reflection corresponding to the face-centered cubic (FCC) structure which is in good agreement with the reported data of M. Shume et al [29]. The powder XRD pattern for the silver oxide nanoparticles with the high intensity peaks observed at $2\theta = 38.11^{\circ}$ along the (1 1 1) hkl plane, $2\theta = 44.21^{\circ}$ along the (2 2 0) hkl plane and $2\theta = 77.60$ along the (3 1 1) hkl plane are shown in

figure (4.1). The absence of impurity peaks reveals that Ag₂O nanoparticles exhibit high crystalline quality.



4.1.1 CALCULATION:

K=0.9
$$\lambda$$
=1.5406×10^-10 m

From equation (1),

$$\mathbf{D} = \frac{\kappa\lambda}{\beta\cos\theta}$$

1. $2\theta = 38.0329$ $\theta = 19.0145$

β=0.1968

 $D = \frac{0.9 \times 1.5406 \times 180 \times 10^{-10}}{0.1968 \times \cos(19.01645) \times 3.14}$

$$= \frac{249.5772 \times 10^{-10}}{0.60936585}$$

$$=40.95687344 \times 10^{-9}$$
m

D = 40.95687344 nm

2. 0=44.2009	θ= 22.10045	β=0.1476
$D = \frac{0.9 \times}{0.147}$	1.5406×180×10 [^] -10 6×cos(22.10045)×3.14	
$=\frac{2^{2}}{6}$	49.5772×10 ⁻¹⁰ 0.4606982988	
= 5	4.173675×10 ⁻⁹ m	
D = 5	54.173675 nm	
3. 20=64.3936	θ= 32.1968	β=0.3936

 $D= -\frac{0.9\times1.5406\times180\times10^{-10}}{0.3936\times\cos(32.1968)\times3.14}$

 $=\frac{249.5772\times10^{-10}}{0.8778613475}$

 $= 28.43014 \times 10^{-9} m$

$$D = 28.43014 \text{ nm}$$

4. 2 θ=77.4066 θ=38.7033 β=0.4920

$$D = \frac{0.9 \times 1.5406 \times 180 \times 10^{-10}}{0.4920 \times \cos(38.7033) \times 3.14}$$
$$= \frac{249.5772 \times 10^{-10}}{0.8292504}$$
$$30.0967 \times 10^{-9}$$

$$= 30.0967 \times 10^{-5}$$

D = 30.0967nm

PEAK	POSITION	MEAN	FWHM	PARTICLE
HEIGHT(cts)	2 0	θ(DEGREE)	β	SIZE D(nm)
	(DEGREE)			
140.91	38.0329	19.01645	0.1968	40.95687
75.57	44.2009	22.10045	0.1476	54.1736
47.85	64.3936	32.1968	0.3936	28.43014
48.04	77.4066	38.7033	0.4920	30.0967

Table 4.1 Calculation of size of silver nanoparticle from XRD pattern

The average size of silver nanoparticle is 38.4143 nm

4.2 CHARACTERISATION USING SEM:

SEM technique is employed to visualize the surface morphology of silver oxide nanoparticles. The SEM images of the AgNPs are shown in Fig. (4.2 - 4.4). The images are almost cubed like structure fig. (4.2) rod shaped fig. (4.3, 4.4) while some of the others are elliptical in shape. The shape of nanoparticles depends on their interaction with stabilizers and the inductors around them and also their preparation method.



Fig 4.2 Scanning Electron Microscope (SEM) image of silver nanoparticles



Fig. 4.3 Scanning Electron Microscope (SEM) image of silver nanoparticles



Fig. 4.4 Scanning Electron Microscope (SEM) image of silver nanoparticles

4.3 CHARACTERIZATION USING EDAX:

The purity of Ag nanoparticles was analyzed by EDX pattern as revealed in Fig. 4.1. Sharp and distinct peak of silver is observed at 3 keV. Thus, presence of sharp and intense peaks of Ag shows the high purity of synthesized nanoparticles. Elemental composition analysis by EDX presented strongest signal from silver (Ag) region and weaker signals from O, P, S and C atoms. It also showed that pure crystalline nature was only composed of silver.



Fig 4.5 Energy Dispersive X-ray analysis (EDAX) of silver nanoparticles

CHAPTER 5

CONCLUSION

CONCLUSION

5.1 CONCLUSION:

In conclusion, silver nanoparticles with mean diameters of 28, 40, 54 and 30 nm were synthesized using Sodium Hydroxide (NaOH) as a reducing agent. The nanoparticles were characterized by EDX, XRD and SEM. XRD show the characteristic plasmon absorption peak for the silver nanoparticles ranging 38 nm. The energy-dispersive spectroscopy (EDX) of the nanoparticles dispersion confirmed the presence of elemental silver particle and no peaks of other impurity were detected.

The size, shape, and morphology of nanoparticles are all controlled by particular criteria such as reaction kinetics, temperature, pH, and so on, so that the synthesis method is selective in producing the nanoparticle that is desired.

Characterization of AgNP is a crucial step in determining their properties and learning about their composition, structure, and morphology. It also allows us to determine when the synthesis process is complete and assess its quality.

Physical and chemical synthesis methods can be used to create silver nanoparticles. Every year, hundreds of research articles detailing various Ag-NP synthesis strategies are published. We have just studied a few of the most important publications through this project, which largely deal with physical and chemical methods. All known applications for metallic silver might employ nanosilver instead of silver to take advantage of nanosilver's unique features, according to the literature. Despite all of nanosilver's advantages, its environmental impact is problematic. These synthesis methods may necessitate the use of various raw materials, as well as the usage of hazardous products or wastes to produce reactions. However, there are various research in the literature regarding nanosilver synthesis methods, but the most widely utilised methods in the industry are yet to be known. As a result, we propose that researchers be directed to work on industrystandard methods for manufacturing nanosilver. In the future, we'd like to carry on further research on nanoparticles, giving importance to bio (green) synthesis of nanoparticles.

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STRUCTURAL AND OPTICAL PROPERTIES OF CuO THIN FILM SYNTHESIZED BY SILAR METHOD

Project report submitted to the Department of Physics

ST. MARY'S COLLEGE (AUTONOMOUS)

THOOTHUKUDI

Affiliated to MANONMANIUM SUNDARANAR UNIVERSITY, TIRUNELVELI

In partial fulfilment of the requirement for the award of BACHELOR'S DEGREE IN PHYSICS

BY

K. Athi Lakshmi	- 19AUPH03
V. Kavya	- 19AUPH19
T. Reena	- 19AUPH35
R. Sakthi Maheshwari	- 19AUPH38
K. Shanmathi	- 19AUPH42
M. Siva Priya	- 19AUPH44

Under the guidance of

Mrs. P. Dhanalakshmi M.Sc., B.Ed., SET



Department of Physics

ST. MARY'S COLLEGE (AUTONOMOUS) Reaccredited with 'A+' Grade by NAAC Thoothukudi 2021-2022

CERTIFICATE

This is to certify that this project work entitled 'STRUCTURAL AND OPTICAL **PROPERTIES OF CUO THIN FILM SYNTHESIZED USING SILAR METHOD' is** submitted to ST. MARY'S COLLEGE (AUTONOMOUS), THOOTHUKUDI in partial fulfilment for the award of Bachelor's degree in Physics and is a record of work done during the year 2021-2022 by the following students.

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Dhanalarshmi.P. GUIDE

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GUIDE

HEAD OF THE DEPARTMENT

EXAMINER

PRINCIPAL

ACKNOWLEDGEMENT

"ACKNOWLEDGING THE GOOD THAT YOU ALREADY HAVE INYOUR LIFE IS THE FOUNDATION FOR ALL ABUNDANCE"

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ABSTRACT

Copper oxide thin films were fabricated by SILAR method. The structural and optical properties were studied. The structural features of the CuO thin films were determined with the help of XRD analysis. The XRD spectrum of the thin films prepared at 0.1 M precursor concentration, grown at room temperature were obtained. XRD spectrum reveals that the sample has polycrystalline CuO phase with a monoclinic crystal structure and with agreed standard data. The peaks were obtained at 2θ =32.47 and 2θ =39.64. In the present work, UNIT CELL software is used to calculate the cell constant and cell volume. In addition to that the structure of the sample is confirmed. The crystallite size was calculated to be D=14.78 nm. The optical properties of CuO thin films were studied using UV-vis spectroscopy. In the UV-vis absorption spectra the peak observed at 348 nm indicates the presence of CuO. The optical band gap was calculated and its value was found to be 3.5 eV.

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INTRODUCTION

CHAPTER I

INTRODUCTION:

In modern material science, thin film technology has a wide range of unique applications and thin film coating technology has been used in electronic and mechanical applications from the beginning of the 20^{th} century. In recent years, metal oxide thin films with unique properties have attracted considerable attention. CuO is a *p*-type semiconductor having an energy gap width of approximately 1.2 eV. CuO is a secondary copper mineral, which is the most stable form of oxidized copper.

The specific physical and chemical deposition strategies used to develop CuO thin film on glass consist of

- reactive sputtering
- chemical vapour deposition
- spraying
- thermal oxidation
- electro deposition
- deposition of CuO via SILAR

Among these techniques, the deposition of CuO via SILAR method has been utilized as a potentially useful technique for preparation of CuO thin film because of its low cost and simple method.

CuO has a monoclinic structure and many remarkable properties such as,

- Superconductivity,
- Catalytic activity,
- Optoelectronic properties,
- High stability and
- Antibacterial activity.

It has various applications such as:

- Solar energy cells,
- Optoelectronics high-temperature superconductors, gas detectors, and giant magneto resistive devices,
- Catalysis,
- Biosensors,
- Photoelectrochemical sensors,
- Supercapacitors,
- Lithium ion batteries,
- Infrared photo detectors,
- Electrochemical sensors and
- Gas sensors.

In this study, we report the preparation of copper oxide thin films by the deposition of CuO via SILAR technique. The structural, optical properties of the prepared thin films were obtained using X-ray diffraction pattern and UV - vis spectroscopy. Various microstructural parameters are evaluated and the results are discussed.

1.1 CORNERSTONE:

The manipulation of materials on an atomic or molecular scale especially to build microscopic devices (such as robots) placing atoms as though they were bricks, nanotechnology will give us complete control over the structure of matter, allowing us to build any substance or structure permitted by the laws of nature. There are four main types of intentionally produced nanomaterials: carbon-based, metal-based, dendrimers. and nanocomposites. Carbon-based nanomaterials are intentionally produced. Nanotechnology can change dental medicine, healthcare and human life profoundly than several developments of the past. However, they even have the potential to evoke important advantages like improved health, higher use of natural resources and reduced environmental pollution.

1.2 FUTURE OF NANOTECHNOLOGY:

In the next 20 years, nanotechnology will touch the life of nearly every person on the planet. The potential benefits are mind boggling and brain enhancing. But like many of the great advancements in earth's history, it is not without risk. Nanotechnology has an impactful and bright future in various fields of application regards to medicine, defense, biotechnology and so on. The compactness of the size is considered to be the great advantage of using this technology. In future, the objects designed with this nanotechnology are capable of harvesting energy from their environment. Currently, many kinds of research have been in the field of nanotechnology so that the materials can be able to develop energy from light, movement, variation in temperature, etc.,



APPLICATIONS OF NANOTECHNOLOGY:



1.3 Nano thin film:

A thin film is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. Thin films are created through a process called "deposition." Deposition is a thin film coating process, which is achieved by modifying the four states of matter - solid, liquid, vapour and plasma. Nanostructured films are commonly created using magnetron sputtering from an appropriate target material. Films can be elemental in nature, formed by sputtering from a pure metal target such as copper or composed of compound materials.

1.4 Applications:

- Thin film materials have been used in semiconductor devices, wireless communications, telecommunications, integrated circuits, rectifiers, transistors, solar cells, light- emitting diodes, photoconductors and light crystal displays, lithography, micro- electro mechanical systems (MEMS) and multifunctional emerging.
- Nano-clays and nanofilms are in use as barrier materials to prevent spoilage by microbes and oxygen absorption. These specific films are used to prevent and reduce the possibility of food drying and spoilage.
- It is used for protecting the surface of many material, especially optical elements, from wear, scratches, fingerprints, and even from corrosion.
- It is used in spectrally selective solar absorbers, solar control glazing, angular selective filters, optical biosensors and decorative paints.

1.5 CuO:

Copper (II) oxide or cupric oxide is an inorganic compound with the formula CuO. The black solid, is one of the two stable oxides of copper, the other being Cu_2O or copper(I) oxide (cuprous oxide). As a mineral, it is known as tenorite. It is a product of copper mining and the precursor to many other copper-containing products and chemical compounds.

Chemical formula	CuO
Molar mass	79.545 g/mol
Appearance	black to brown powder
Density	6.315 g/cm ³
Melting point	1,326 °C (2,419 °F; 1,599 K)
Boiling point	2,000 °C (3,630 °F; 2,270 K)
Solubility in water	Insoluble
Solubility	Soluble in ammonium chloride, potassium cyanide insoluble in alcohol, ammonium carbonate
Band gap	1.2 eV
Magnetic susceptibility (χ)	$+238.9 \cdot 10^{-6} \text{ cm}^{3}/\text{mol}$
Refractive index (<i>n</i> D)	2.63
Thermochemistry	
Std molar entropy (S 298 ⁰)	$43 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$
Std enthalpy of formation ($\Delta f H \xrightarrow{\frown} 298$)	$-156 \text{ kJ} \cdot \text{mol}^{-1}$



Powder form of CuO

1.6 STRUCTURE OF CuO:



Structure	
Crystal structure	monoclinic, mS8
Space group	C2/c, 15
Lattice constant	a = 4.6837, b = 3.4226, c = 5.1288 $\alpha = 90^{\circ}, \beta = 99.54^{\circ}, \gamma = 90^{\circ}$

1.7 **PROPERTIES OF CuO:**

Chemical data:

Chemical symbol	CuO
CAS no	1317-38-0
Group	Copper 11
	Oxygen 16
Electronic configuration	Copper [Ar]3d ¹ 4s ¹
	Oxygen [He] 2s ² 2p ⁴

Chemical Composition:

Element	Content (%)
Copper	79.87
Oxygen	20.10

Physical Properties:

Properties	Metric	Imperial
Density	6.31 g/cm ³	0.227 lb/in ³
Molar mass	79.55 g/mol	

Thermal Properties:

Properties	Metric	Imperial
Melting point	1201°C	2194°F
Boiling point	2000°C	3632°F

1.8 OBJECTIVES:

- \checkmark To give an overview of the preparation of CuO thin-film.
- ✓ To synthesis pure copper oxide thin-film by SILAR method.
- \checkmark To realize the potential applications at nanoscale.
- \checkmark To provide a critical discussion of the synthesis of CuO thin-film.
- ✓ To provide evidence for the monoclinic structure of CuO thin-films using XRD studies.
- \checkmark To calculate the crystallite size by using Scherrer's equation.
- \checkmark To obtain the peak using FTIR spectrum to confirm the presence of CuO.
- \checkmark To study the optical properties of copper oxide thin film by UV-vis spectroscopy.

LITERATURE REVIEW
CHAPTER II LITERATURE REVIEW

Tatsumi Ishihara, Masakazu Higuchi have prepared CuO thin films by decomposition of selfassembled multibilayer films as a molecular template was investigated. Furthermore, the CO₂ sensing property of the resultant CuO thin films on a porous BaTiO₃ was investigated as a capacitive type sensor. Self- assembled bilayer films of a few 1000 layers thickness can be readily obtained by casting an aqueous suspension composed of dimethyl dihexadecyl ammoniun bromide (DC1–16), Cu(CH₃CO₂)₂, hexadecyl ethylene diamine and poly(vinylalcohol). Divalent copper ions (Cu²⁺) which are associated with two hexadecyl ethylene diamine molecules were arranged in the hydrophobic layer of the multibilayer film. Rapid heating to the combustion temperature of DC1-16 was desirable for removing organic molecules in the multibilayer template. Thin films of CuO can be obtained by calcination at temperatures higher than 573 K. The resultant CuO thin films were porous and consisted of fine particles. The capacitance of CuO thin films prepared from selfassembled multibilayer films as a molecular template on the BaTiO₃ porous substrate exhibited a high sensitivity to CO₂, which is twice that of a conventional mixed oxide capacitor of CuO-BaTiO₃. The capacitance of CuO thin films on BaTiO₃ increases with increasing CO2 concentration in the range from 100 ppm to 50% at 873 K. Consequently, it is concluded that CuO thin films on BaTiO₃ were appropriate capacitive type CO_2 sensor.

Hassan Zare Asla has prepared CuO thin films on glass substrates at a wide range of temperatures from 450°C to 550°C with steps of 25°C by chemical spray pyrolysis technique. Aiming to investigate the effect of annealing process, one of the resulting films was annealed at 450°C for 3 hours under ambient air. Based on X-ray diffraction, all the resulting films are monoclinic with two prominent peaks at \sim 36° and \sim 39°. The crystallite size of the CuO film deposited at 450°C was found to be the largest in comparison with the others. As the substrate temperature increased, a gradual change was observed for the CuO thin film surface morphology and in the case of annealed film, the grains and their boundaries became indistinguishable. The resistivity of the films was reduced by virtue of increasing the substrate temperature and also, both the mobility and carrier concentration of the annealed film were improved drastically after annealing. As expected, the CuO thin films absorption was considerable in the visible region and

gradually declined after 800nm. The estimated band gap value of the CuO film deposited at 450°C were fairly close to the optimum band gap for solar applications.

Diwakar Chauhan, Satsangi, have prepared Nanostructure copper oxide thin films (CuO) were prepared on conducting glass support (SnO2: F over layer) via sol–gel starting from colloidal solution of copper (II) acetate in ethanol. Films were obtained by dip coating under room conditions (temperature, 25–32°C) and were subsequently sintered in air at different temperatures (400–650°C). The evolution of oxide coatings under thermal treatment was studied by glancing incidence X-ray diffraction and scanning electron microscopy. Average particle size, resistivity and band gap energy were also determined. Photo electrochemical properties of thin films and their suitability for splitting of water were investigated. Study suggests that thin films of CuO sintered at lower temperatures ($\approx 400^{\circ}$ C) are better for photo conversion than thick films or the films sintered at much higher temperatures. Plausible explanations have been provided.

V. Patil, D. Jundale have prepared nanocrystalline copper oxide (CuO) thin films were deposited onto glass substrates by a spin coating technique using an aqueous solution of copper acetate. These films were characterized for their structural, morphological, optoelectronic properties by means of X-ray diffraction (XRD) scanning electron microscopy (SEM), UV spectroscopy and four probe method. The CuO films are oriented along (1 1 1) plane with the monoclinic crystal structure. These films were utilized in H₂S sensors. The dependence of the H₂S response on the operating temperature, H₂S concentration of CuO film (annealed at 700^oC) was investigated. The CuO filmshowed selectivity for H₂S. The maximum H₂S response of 25.2 % for the CuO film at gas concentration of 100 ppm at operating temperature 200° C was achieved.

Y.F. Lim, C. S. Chua have prepared CuO thin films by a sol–gel spin-coating process. Sol–gel deposition has distinctive advantages such as low-cost solution processing and uniform film formation over large areas with a precise stoichiometry and thickness control. Pure-phase Cu₂O and CuO films were obtained by thermal annealing at 500 °C in nitrogen and ambient air, respectively. The films were successfully incorporated as photocathodes in a photo electrochemical (PEC) cell, achieving photocurrents of -0.28 mA cm⁻² and -0.35 mA cm⁻² (for Cu₂O and CuO, respectively) at 0.05 V a reversible hydrogen electrode (RHE). The Cu₂O photocurrent was enhanced to -0.47 mA cm⁻² upon incorporation of a thin layer of a NiO_x co-

catalyst. Preliminary stability studies indicate that CuO may be more stable than Cu_2O as a photocathode for PEC water-splitting.

Khawla Khashan has prepared CuO thin films spray pyrolysis method using different concentration of CuCl₂ .2H₂O. X- ray diffraction (XRD) and UV-VIS transmission spectroscopy were employed to characterize the structure and optical properties of prepared films. XRD patterns show that the films are polycrystalline and monoclinic with (-111) and (111) crystalline orientations. The optical band gaps (2.05 to 2.42eV), with high absorption coefficient change from (3*105 - 1*105) cm⁻¹ at 0.3M concentration and excitation coefficient change from (0.85 - 0.7). These constants are found to be oscillatory in nature, which are attributed to the particular structure of films and their concentration.

Ashwin Kumar, Saikumar have prepared CuO thin films utilizing RF sputtering technique with deposition occurring at room temperature followed by thermal annealing between 100°C and 400°C and using different gases, oxygen (O₂) (oxidizing and reactive gas) and nitrogen (N₂) (inert gas), besides air. Afterwards, these thin films were evaluated for a range of wavelengths: 200 - 400 nm (UV spectrum), 400 - 700 nm (Visible spectrum), and 700 - 800 nm (IR spectrum), for both, optical transmittance and photoluminescence. In addition, the CuO results were compared to our Cu₂O results from a previous study to assess their differences. In the results of this study, the CuO thin film initially had a bandgap of 2.19 eV at room temperature and by increasing the annealing temperature to different levels, the bandgap decreased respectively. The presence of air in the chamber allowed for the highest decrease, followed by the nitrogen (N₂) and the lowest decrease was observed in the presence of oxygen (O₂). This was reflected in the decrease in the bandgap values from 2.19 eV (room temperature) to 2.05 eV for the films annealed at 400°C.

Shinho Cho has prepared Copper oxide thin films deposited on glass substrates at various growth temperatures by the reactive radio-frequency magnetron sputtering method. The band gap energy, carrier concentration and figure of merit of the CuO thin films were found to depend significantly on the growth temperature. All of the CuO films, irrespective of growth temperature, showed a monoclinic structure with the main CuO $(1\overline{11})(1\overline{11})$ orientation, and the crystallite size, determined by using Scherrer's formula, was about 50 nm for the thin film deposited at 25 °C. The highest figure of merit occurred for the film grown at 300°C with an optical transmittance of 62.9% in the wavelength range of 800–1100 nm. The results suggest that the optimum growth temperature for growing high-quality CuO thin films is 300 °C.

Mohammad has prepared Al-doped CuO thin film by the thermionic vacuum arc technique. The microstructural, morphological and optical properties were investigated. According to the X-ray diffraction patterns, the polycrystalline CuO material was obtained by means of the Al doping element. Using the Scherrer formula, the calculated crystallite size values are between 11 and 28 nm in different reflection planes. The thickness of the film was 50 nm. In the optical analysis, the average transmittance, absorbance and refractive index were 74%, 0.13 and 2.05 respectively. The optical band gap was 2.13 eV, which is in good agreement with the photoluminescence result. In the doping by Al, the band gap of the CuO shifted towards the visible region.

Toshiro Maruyama has prepared polycrystalline copper oxide thin films at a reaction temperature above 280°C by an atmospheric pressure chemical vapour deposition method. The source materials were copper dipivaloyl-methanate and oxygen. It has been shown from the experiment that two kinds of films, i.e., Cu₂O and CuO are grown by controlling oxygen partial pressure. A series of characterizations on the film quality by scanning electron microscope, X-ray photoelectron spectroscopy, X-ray diffraction and Fourier transform infrared spectrometer has been made and the performance of solar thermal conversion are also identified on the produced films. Results show that the well-crystallized CuO film has lower infrared transmittances due to the scatterings of light through the optically anisotropic monoclinic structure.

Y. S. Lee, D. Chua have prepared nanostructured copper oxide thin films (CuO) on conducting glass support (SnO₂: F over layer) via sol–gel starting from colloidal solution of copper (II) acetate in ethanol. Films were obtained by dip coating under room conditions (temperature, $25-32^{\circ}$ C) and were subsequently sintered in air at different temperatures (400–650°C). The evolution of oxide coatings under thermal treatment was studied by glancing incidence X-ray diffraction and scanning electron microscopy. Average particle size, resistivity and band gap energy were also determined. Photo electrochemical properties of thin films and their suitability for splitting of water were investigated. Study suggests that thin films of CuO sintered at lower temperatures ($\approx 400^{\circ}$ C) are better for photo conversion than thick films or the films sintered at much higher temperatures. Plausible explanations have been provided.

EXPERIMENT

Chapter III

EXPERIMENT

3.1 Synthesis of thin-film:

In order to obtain thin films with good quality, there are two common deposition techniques: physical and chemical depositions.

*Vacuum thermal evaporation

*Chemical vapour deposition (CVD)

- ► Low pressure (LPCVD)
- Plasma enhanced (PECVD)
- Atomic layer deposition (ALD)



Vacuum thermal evaporation



Chemical vapour deposition (CVD)

3.2 SILAR METHOD:

A successive ionic layer adsorption and reaction (SILAR) method is one of the chemical methods for making uniform and large area thin films, which is based on immersion of the substrate into separately placed cations and anions.



3.3 Preparation of Copper Oxide thin films:

The glass substrates were washed with ethanol and then rinsed with distilled water. It was then hung in air to dry. Solution of Copper Sulphate complex was prepared by adding 5ml of Ammonia (NH₃) (25%) to copper sulphate solution. To deposit CuO thin film, one SILAR cycle involves the following four steps :

- ✤ A well cleaned glass substrate was first immersed into cationic precursor, so that the Cu²⁺ ions were adsorbed into the surface of the substrate.
- Then the substrate was rinsed with distilled water for 30s to remove loosely bonded Cu²⁺ ions from the substrate.
- ★ The substrate was immersed into $H_2O \ 90^0C$ for 10s so that the OH^{2+} ions were adsorbed.
- \clubsuit Now, the substrate was allowed to dry in air for 60s.
- Again the substrate was rinsed with distilled water for 30s to remove loosely bound OH²⁻ ions from the substrate.

The procedure was carried out at room temperature. The above cycle was carried out for about 30 times to obtain CuO thin-film.



MATERIALS AND METHODS

Chapter IV

MATERIALS AND METHODS

4.1 Chemicals:

- CuCl₂ copper chloride
- Aqueous ammonia NH₃
- Double distilled water
- Acetone
- 1:1 ethanol
- Copper ammonia complex (Cu(NH₃)₄)²⁺

4.2 Experimental studies:

Synthesis of Cuo thin film:

In a typical synthesis, the glass substrates should be cleaned ultrasonically for 10 mins, first in acetone and then in a 1:1 ethanol water solution. The substance is dried and stored in desiccators. To prepare 0.1M CuCl₂ solution add CuCl₂ in 100ml of double distilled water and stir the mixture to obtain a well dissolved solution. The pH of the solution should be adjusted to ~10 by adding aqueous ammonia (NH₃) 25-28%. Thus a copper ammonia complex $[Cu(NH_3)_4]^{2+}$ is obtained. Immerse the substrate in $[Cu(NH_3)_4]^{2+}$ solution for 30 seconds to create a thin liquid film containing $[Cu(NH_3)_4]^{2+}$ on the substrate. Now immerse the substrate in hot water immediately (90^oC) for 7 seconds to form CuO layer. Dry the substrate in air for 60 seconds. Rinse the substrate in a separate beaker for 30 s to remove large and loosely bound CuO particles. Repeat the cycle for 40 times and more.

Ammonia as reducing agent

In ammonia, the nitrogen atom has one lone pair of electrons which it can donate and oxidize (loss of electrons) itself. The species which accepts this lone pair of electrons will be reduced. It is a strong reducing agent. Reduction of copper oxide:

 $3 \ CuO + 2 \ NH_3 \rightarrow 3 \ Cu + N_2 + 3 \ H_2O.$





4.3 CHARACTERIZATION TECHNIQUES:

In the past years, the advancement in science has taken place mainly with the discovery of new materials. Characterization is an important step in the development of exotic materials. The complete characterization of any material consists of phase analysis, compositional characterization, structural and surface characterization, which have strong bearing on the properties of materials. In this section, different analytical technique used to characterize our thin films are described with relevant principles of their operation and working.

4.4 X- ray Diffraction (XRD) Technique:

X-ray diffraction (XRD) is a powerful technique for determination of crystal structure and lattice parameters. Much of our knowledge about crystal structure and the structure of molecules as complex as DNA in crystalline form comes from the use of x-rays in x-ray diffraction studies. A basic instrument for such study is the Bragg's spectrometer.



Diffraction in general occurs only when the wavelength of the wave motion is of the same order of magnitude as the repeat distance between scattering centers. This condition of diffraction is nothing but Bragg's law and is given as,

$$2d \sin \theta = n\lambda$$

where

d = interplanar spacing $\theta = diffraction angle$

 λ = wavelength of x-ray

n = order of diffraction

For thin films, the powder technique in conjunction with diffractometer is most commonly used. In this technique the diffracted radiation is detected by the counter tube, which moves along the angular range of reflections. The intensities are recorded on a computer system. The 'd' values are calculated by knowing the values of θ , λ and n. The X-ray diffraction data thus obtained is printed in tabular form on paper and is compared with Joint Committee Power Diffraction Standards (JCPDS) data to identify the unknown material. The sample used may be powder, single crystal or thin film. The crystallite size of the deposits is estimated from the full width at half maximum (FWHM) of the most intense diffraction line by Scherrer's formula as follows

$$\mathbf{D} = \frac{\mathbf{0.9}\,\lambda}{\beta \, \boldsymbol{cos\theta}}$$

where

D is peak (FWHM) in radians, θ is Bragg's angle. The X- ray diffraction data can also be used to determine the dimension of the unit cell. This technique is not useful for identification of individuals of multilayers or percentage crystallite size, λ is wavelength of X-ray used, β is full width at half maxima of the of doping material.

Applications:

- To measure thickness of thin films and multi-layers.
- The electron density and accordingly, the position of the atoms in complex structures, may be determined from a comprehensive mathematical study of the x-ray diffraction pattern.
- The powder XRD pattern may be thought of as finger print of the single crystal structure, and it may be used to conduct qualitative and quantitative analysis.
- XRD can also be used to determine whether the compound is solvate or not. It is used to access the weathering and degradation of natural and synthetic minerals.
- Tooth enamel and dentine have been examined by XRD.

4.5 UV spectroscopy:

The unique optical properties of metal nanoparticles are a consequence of the collective oscillations of conduction electrons, which when excited by electromagnetic radiation are called surface plasmon polariton resonances. Those changes have an influence on the refractive index next to the nanoparticle's surface; thus, it is possible to characterize nanomaterials using UV–Vis spectroscopy. Besides, nanoparticles have optical properties that are very sensitive to nanoparticles size, shape, aggregation (agglomeration) problems, the structure of the particles, concentration changes, etc. Hence a method that is versatile, reliable, and economical, like UV–Vis spectroscopy, can be used for the characterization of nanoparticles even at very low concentrations.

Absorption spectroscopy uses electromagnetic radiation between 190 and 800 nm and is divided into the ultraviolet (190–400 nm) and visible (400– 800 nm) regions. Because the absorption of ultraviolet or visible radiation by a molecule leads to a transition among electronic energy levels of the molecule, it is also often called electronic spectroscopy. The

information provided by this spectroscopy when combined with other sources of spectral data provides clues to valuable structural information of various molecules.

In UV–Vis spectroscopy, the intensity of light that is passing through the sample is measured. UV–Vis spectroscopy is a fast and easy-to-operate technique for nanoparticles characterization, especially for colloidal suspensions. There are several advantages of UV–Vis techniques, such as simplicity, sensitivity and selectivity to nanoparticles and short time of measurement and what is more, calibration is not required. Therefore, these techniques are increasingly used for nanoparticle characterization in many fields of science and industry.

Measurement of optical properties of nanomaterials based thin films by means of UV–Vis spectroscopy. UV–Vis spectroscopy, specifically, allows us to understand the following optical properties of thin films:

- \circ Optical transmittance (*T*) of semiconductor thin films
- \circ Refractive Index (*n*)
- \circ Film thickness (d)
- Absorptance (k)
- Absorption coefficient (ε)
- Band gap (E_g) of thin films
- Nanoparticles' size and shape dependent optical properties (e.g., Tunable Localized Surface Plasmon Resonance Spectra)

RESULT AND DISCUSSION

STRUCTURAL ANALYSIS:

X-ray diffraction techniques are a very useful characterization tool to study, nondestructively, the crystallographic structure, chemical composition and physical properties of materials. It can also be used to measure various structural properties of these crystalline phases such as strain, grain size, phase composition, and defect structure.

The grain size of the sample is calculated using Scherrer's formula,

$$\mathbf{D} = \mathbf{K} \, \lambda / \, \beta \, \cos \, \theta$$

Where

 $D \rightarrow Grain size$

 $\lambda \rightarrow$ Wavelength of α -ray used (1.54060A)

 $K \rightarrow$ Scherrer's constant (≈ 0.9)

 $\beta \rightarrow$ Full width at half maximum

 $\theta \rightarrow \text{Diffraction angle}$

Unit cell software:

Unit Cell is a program. It refines cell parameters from powder diffraction data. Unlike most existing cell refinement programs it does not require initial estimates for cell constants; it uses a non-linear least squares method, which allows the refinement to be carried out on the actual observed data (e.g. two-theta in the case of angle-dispersive monochromatic diffraction, energy in the case of energy-dispersive diffraction). These diagnostic tools are particularly valuable in assessing the sensitivity of the calculated results to the observations of individual Bragg peaks.

In the present work, UNIT CELL software is used to calculate the cell constant and cell volume. In addition to that the structure of the sample is confirmed.

Output from program Unit Cell - Method of TJB Holland & SAT Redfern 1995

Sample title: CuO

Refined in monoclinic system, using wavelength 1.540600 Å, minimizing the sum of squares of residuals in 2 theta

Weighted assuming a value of sigma(2theta) = 0.005 deg

Parameter	Value	Sigma	95% conf
а	4.62434	0.00046	0.00144
b	3.43311	0.00027	0.00085
С	5.06117	0.00064	0.00202
beta	84.38928	0.01268	0.04010
cell vol	79.9657	0.0138	0.0436

Cell parameter errors scale in direct proportion to this weighting value

Residuals: Standard, average and maximum deviations:-

std (2T) = 1.9133 and (2T) = 1.4611; max dev (2T) = 3.3971

sigma fit = 584.5172

students t = 3.16

Correlation matrix:

	a	b	c	beta
а	1.000			
b	-0.099	1.000		
С	-0.173	-0.005	1.000	
beta	0.301	0.026	0.368	1.000

Cell Parameters of PbS

Sample	Structure	Cell Constant (Å)	Cell Volume (Å)
CuO	Monoclinic	a = 4.6243 b = 3.433 c = 5.06117	79.9657

	a*	b*	c*	beta*
params	0.2172879	0.2912807	0.1985340	95.6107
sigma	0.0000234	0.0000228	0.0000270	0.0127

Reciprocal cell parameters:

Observed and fitted results: {dependent-variable residuals >2sd are bulleted}

no	h	k	1	d(obs)	D(calc)	res(d)	2T.obs	2T.calc	rest(2T)
1	1	0	0	5.46360	4.60219	0.86141	16.210	19.271	-3.061*
2	1	1	0	2.75523	2.75180	0.00343	32.470	32.512	-0.042
3	0	0	2	2.51846	2.51846	0.00000	35.620	35.620	-0.000
4	1	1	1	2.27183	2.47659	-0.20476	39.640	36.243	3.397
5	2	0	0	2.22082	2.30109	-0.08027	40.590	39.115	1.475
6	2	0	2	1.82542	1.78806	0.03736	49.920	51.037	-1.117
7	0	2	0	1.75124	1.71656	0.03468	52.190	53.327	-1.137

Regression diagnostics (for deletion of each observation i):

no	h	k	l	hat	dfFits	Rstudt	sigma[i]	d(sig)%
3	0	0	2	1.000	-11208.118	-0.026	715.7629	22.5
5	2	0	0	0.766	1.935	1.068	571.2065	-2.3
6	2	0	2	0.911	-4.940	-1.547	482.9500	-17.4
7	0	2	0	0.810	-1.706	-0.851	613.3229	4.9
Limit:				1.000	1.512	2.000		

(a) Potentially deleterious or influential observations affecting the fit:

(b) Observations most strongly affecting the parameter values

DfBetas: cell parameter changes (as % of their standard deviations):

no	h	k	1	da	db	dc	dbeta	dv
1	1	0	0	-32144	2656	2135	-14927	-17175
			-					
2	1	1	0	-218	-312	23	-132	-267
3	0	0	2	-841340	14	794468	-403740722	581128
4	1	1	1	1006	22278	2440	-17752	10667
5	2	0	0	90558	-9547	-14894	53148	47946
6	2	0	2	-122878	22278	-94398	170358	-59080
7	0	2	0	10571	-118053	477	-2859	-46907

The XRD pattern of the sample CuO thin film is shown in figure 1. The X-ray diffraction pattern of CuO displays two intense peaks and 2θ values are given in table 1. The values agree well with the standard value of CuO (JCPDS Card No.48 - 1548). The diffraction peaks observed at 2θ values of 32.47 °, 39.64° and the d spacing calculated indicates that the structure corresponds to the monoclinic structure of CuO.





Table 1: Grain size calculation of CuO

Sample	Observed 2 0 (deg)	FWHM (Radians)	Grain Size (nm)	Average grain size (nm)
--------	--------------------------	-------------------	--------------------	----------------------------

CuO	32.47 39.64	0.5904 0.5904	14.63 14.93	14 .78

UV-VIS SPECTROSCOPY:

Figure (3) shows the UV-vis absorption spectra of the CuO thin film synthesized at 100° C. The peak at 348 nm is due to the presence of CuO.



FIGURE (3)

The optical band gap E_g in eV can be calculated using absorption edge values (λ edge in nm) from absorption spectra by using

1240/λ

The calculated band gap value is 3.5 eV. The obtained higher value of band gap of CuO film can beascribed to quantum confinement effect. The higher values are due to stoichiometry, crystallinity anddensityandoxygenvalencies.

CONCLUSION

CHAPTER VI

CONCLUSION

6.1 Summary:

In this investigation, copper oxide thin-films were prepared by SILAR method. The structural and optical properties were studied. The structural features of the CuO thin films were determined with the help of XRD analysis. The XRD spectrum of the thin films prepared at 0.1 M precursor concentration, grown at room temperature were obtained.

The X-ray diffraction pattern of CuO displayed two intense peaks and 2θ values which were in agreement with the standard value of CuO (JCPDS Card No.48 - 1548). The diffraction peaks observed at 2θ values of 32.47° , 39.64° and the d-spacing calculated indicates that the structure corresponds to the monoclinic structure of CuO. The UNIT CELL software is used to calculate the cell constant and cell volume. In addition to that, the structure of the sample is confirmed. The crystallite size was calculated to be D=14.78 nm.

The optical properties of CuO thin film were studied using UV-vis spectroscopy. In the UV-vis absorption spectra the peak observed at 348 nm indicates the presence of CuO. The optical band gap was calculated and its value was found to be 3.5 eV.

This study is an evident proof that copper oxide thin films can be prepared in a simple and cost effective manner using SILAR method to satisfy the needs of various applications in the future.

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CERTIFICATE

This is to certify that the project work entitled "SOIL MOISTURE SENSOR USING ARDUINO UNO" is submitted to St. Mary's College (Autonomous), Thoothukudi in partial fulfilment for the award of the Bachelor's Degree in Physics and is a record of work done during the year 2021 – 2022 by the following students.

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ABSTRACT

Soil moisture is directly related to the amount of irrigation in agriculture and influences the yield of crops. Accordingly, a soil moisture sensor is an important tool for measuring soil moisture content. In this study, the previous research conducted in recent 2-3 decades on soil moisture sensors was reviewed and the principles of commonly used soil moisture sensor and their various applications were summarized. Furthermore, the advantages, disadvantages, and influencing factors of various measurement methods employed were compared and analyzed. The improvements were presented by several scholars have established the major applications and performance levels of soil moisture sensors, thereby setting the course for future development. These studies indicated that soil moisture sensors in the future should be developed to achieve high-precision, low-cost, non-destructive, automated, and highly integrated systems. Also, it was indicated that future studies should involve the development of specialized sensors for different applications and scenarios. This review research aimed to provide a certain reference for application departments and scientific researchers in the process of selecting soil moisture sensor products and measuring soil moisture.

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CHAPTER – I

INTRODUCTION

1.1 Introduction to Soil Moisture Sensor Using Arduino

India is a country where majority of our population are dependable on the Agriculture to live the daily life. In this modern technological era farmers of India can't get enough assistance from others to help them with technology and make their work easier.

Developments in technology, Science and medicine have allowed a much better quality and longevity of a man's life, leading to a continuous increase in population. Consequently requirements for adequate quantities of food and drinking water has increased, as well as need to improve its quality, where the sources are limited.

Soil moisture measurement is of great importance for applications in the field of agriculture allowing farmers to more efficiently manage the irrigation systems. Knowing the exact properties of the soil farmers are not only able to use less water to grow crops, but also increase production and quality, irrigating the plants in the critical periods of its growth.

Soil moisture sensor when used with Arduino UNO measures the volumetric content of water inside the soil and gives us the moisture level as output. The sensor is equipped with both analog and digital output, so it can be used in both analog and digital mode. All living things need water to survive. But for plants and agriculture, having just the right amount of water is crucial. Since it is impossible to visually observe moisture levels in the soil with our naked eyes, Soil moisture sensor plays an important role to provide insights into agriculture.

1.2 Aim of the project

- To write a program in Arduino UNO.
- To measure the soil moisture content using analog and digital programs.
- To use water in a required amount and to increase the productivity in agriculture.

CHAPTER – II

LITERATURE REVIEW

In the year 2009, Sangkil Kim. for the first time demonstrated novel ink-jet printer passive RFID-enabled soil moisture sensor on paper for agricultural purposes. A prototype made of passive RFID tag integrated with a capacitance sensor consisted of printed interdigitated capacitor (IDC) was printed on low-cost paper substrate. The sensor demonstrated shift of minimum power level due to soil moisture variation.

Slobodan Birgermajer. (2011) developed a novel miniature soil moisture sensor based on bandstop structures. Two sensors were designed that integrated conventional RFID systems for practical large scale agricultural applications with microstrip technology used for measurement and mapping of soil moisture in available land. The proposed two novel sensors which operate at 2.54 GHz and 2.75GHz offered two times wider ranges of phase delay. Sensor solutions significantly improved phase shift ranges and sensitivities compared to conventional microstrip sensors.

Kun Xu proposed a twostep β method is suitable for calibration of soil moisture sensor. A capacitive measurement circuit was designed based on resonant principle. A relationship between soil moisture model (β model) sensor output was obtained. Bianca Will et al. (2014) developed a miniature soil moisture sensor that was based on. TDT. The sensor has sensitive part in the form of one wire line and the feeding structure works on basis of concentric coaxial lines. It provides access to large cross sectional area and large soil volume.

G.J. Gaskin . in the year 1995 designed a probe to measure soil water level using an impedance measuring system. The probe costs less, is easily constructed and can withhold field conditions. Jose Antonio et al. (2008) presented design and construction of soil moisture sensor (ITM-01) which used network called back propagation neural network. The output of the proposed sensor, after the learning phase, matched with TDR based measurements. Harlow et al. (2003) used two TDT techniques to derive water content of saturated sands with wide range of pore water electrical conductivities. This was done by connecting two rods parallel transmission line to the network

analyser. TDT method was compared with frequency based methods by converting measurements into frequency domain using Fourier transforms.

Hook (2004) also conducted a similar study comparing TDT with TDR. Guneet Mandar.(2014) proposed design for capacitive sensor that can monitor soil moisture content and analyze analog voltage with varying moisture. Two aluminium knitting needles were used as probes. It was observed that both analog voltage and capacitance follow linear pattern in addition of water.

The dielectric constant (also known as permittivity or specific inductive capacity) ε , is a measure of how polarisable a material is when subjected to an electric field (Zegelin, 1996). This material property is usually measured relative to that of free space, and is referred to as the relative dielectric constant εr . Soil consists of air, soil particles and water. Therefore the relative dielectric constant of soil is a composite of its components (Jackson, 1996). Soil moisture content can be determined from measurements of the soil dielectric constant, as a result of the large difference between the relative dielectric properties of liquid water (approximately 80) and dry soil (2 to 5) (Jackson et al., 1981; Schmugge, 1985; Engman and Chauhan, 1995). Since the dielectric constant is a volume property, the volumetric fraction of each component is involved. Thus, as the soil moisture content increases, the relative dielectric behaviour of moist soil and the commonly used dielectric mixing models are given in a subsequent section.

When a potential is placed across the plates of a capacitor containing a dielectric, charges induced by polarisation of the material act to counter the charges imposed on the plates. Hence, the capacitance between two parallel plates is a function of the dielectric constant of the dielectric (Zegelin, 1996). Parallel plate probes have been widely used in laboratory determination of moisture content of porous materials, but their use in the field is less convenient because of the problem with plate insertion and soil disturbance. More recent capacitance probes are split cylindrical electrodes that may be buried in the soil or positioned at different depths down plastic access tubes embedded in soil (Zegelin, 1996).
CHAPTER – III

SOIL MOISTURE SENSOR AND ARDUINO UNO

3.1 Soil Moisture Sensor

Most soil moisture sensors are designed to estimate soil volumetric water content based on the dielectric constant (soil bulk permittivity) of the soil. The dielectric constant can be thought of as the soil's ability to transmit electricity. The dielectricconstant of soil increases as the water content of the soil increases. This response is due to the fact that the dielectric constant of water is much larger than the other soil components, including air. Thus, measurement of the dielectric constant gives a predictable estimation of water content.

This sensor mainly utilizes capacitance to gauge the water content of the soil (dielectric permittivity). The working of this sensor can be done by inserting this sensor into the earth and the status of the water content in the soil can be reported in the form of a percent. This sensor makes it perfect to execute experiments within science courses like environmental science, agricultural science, biology, soil science, botany, and horticulture

Since it is impossible to visually observe moisture levels in the soil with our naked eyes, soil moisture sensors play an important role to provide insights into your irrigation systems. Soil Moisture Sensors also enable us to develop smart agricultural systems that respond to environmental conditions automatically. we can use an Arduino microcontroller to receive the soil moisture readings.

A Soil Moisture Sensor can either use resistance or capacitance changes to measure the water content of the soil. A resistive soil moisture sensor works by using the relationship between electrical resistance and water content to gauge the moisture levels of the soil. We'll observe these sensors to possess two exposed probes that are inserted directly into the soil sample.



- 1. A electrical current is sent from one probe to the other, which allows the sensor to measure the resistance of the soil between them.
- 2. When the water content in the soil is high, it has a higher electrical conductivity (water is a good conductor of electricity). Hence, a lower resistance reading is obtained which indicates high soil moisture.
- 3. When the water content in the soil is low, it has poorer electrical conductivity. Hence, a higher resistance reading is obtained, which indicates low soil moisture.

3.1.1 The Module

The sensor contains a fork-shaped probe with two exposed conductors that goes into the soil or anywhere else where the water content is to be measured.



The sensor also contains an electronic module that connects the probe to the Arduino.

The module produces an output voltage according to the resistance of the probe and is made available at an Analog Output (AO) pin. The same signal is fed to a LM393 High Precision Comparator to digitize it and is made available at an Digital Output (DO) pin.



The module has a built-in potentiometer for sensitivity adjustment of the digital output (DO). This setup is very useful when you want to trigger an action when certain threshold is reached.



Status LED

Apart from this, the module has two LEDs. The Power LED will light up when the module is powered. The Status LED will light up when the digital output goes LOW.

3.1.2 Soil Moisture Sensor Pinout

The soil moisture sensor is super easy to use and only has 4 pins to connect.



SOIL MOISTURE SENSOR WITH PROBES

- AO (ANALOG OUTPUT): Pin gives us an analog signal between the supply value to 0V and will be connected to one of the analog inputs on your Arduino.
- DO (DIGITAL OUTPUT): Pin gives Digital output of internal comparator circuit. We can connect it to any digital pin on an Arduino or directly to a 5V relay or similar device.
- VCC : Pin supplies power for the sensor. It is recommended to power the sensor with between 3.3V 5V. Please note that the analog output will vary depending on what voltage is provided for the sensor.
- GND: Is a ground connection.

3.2 Arduino UNO

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. We can tell our board what to do by sending a set of instructions to the microcontroller on the board. To do so we use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. The ArduinoUno isan open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo.



ARDUINO UNO

The word "uno" means "one" in Italian and was chosen to mark the initial release of Arduino Software. The Uno board is the first in a series of USB-based Arduino boards; it and version 1.0 of the Arduino IDE were the reference versions of Arduino, which have now evolved to newer releases. The ATmega328 on the board comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.

3.3 CIRCUIT CONNECTIONS

- Connect the two pins from the Sensor to the two pins on the Amplifier circuit via hook up wires.
- Connect the Vcc from the Amplifier to the 3.3V pin on the Arduino and the Gnd pin to the Gnd pin on the Arduino.
- 3. Now connect the Analog Data Pin to the A0 pin on the Arduino.



SOIL MOISTURE SENSOR ARDUINO CONNECTIONS

9

CHAPTER - IV

CODING AND OUTPUT

4.1 Program And Execution

int sensorPin= A0; int sensorValue; int limit=300;

void setup(){
Serial.begin(9600);
pinMode(13, OUTPUT);
}

void loop(){

sensorValue=analogRead(sensorPin); Serial.println("Soil Moisture Content : "); Serial.println(sensorValue);

```
if(sensorValue<limit)
{
digitalWrite(13, HIGH);
}
else{
digitalWrite(13, LOW);
}
```

delay(1000);

10

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soil_moisture_sensor	12
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delay(loo);	
Reach uses 2250 bytes (7%) of program storage space. Maximum is 32256 bytes.	
oldea variables use lik bytes (10%) of dynamic memory. Leaving 1934 bytes for local variables. Maximum is 2041 bytes.	

4.1.2 Program Explanation

1. At the time we start writing the code, we define 3 variables.

int sensorPin= A0;

- Printer and the second second
- 2. The first one defines the analog pin of the Arduino.

int sensorValue;

3. The second defines the analog value of the sensor read by the Arduino.

int limit=300;

4. The third defines a limit.

void setup(){

}

Serial.begin(9600); pinMode(13, OUTPUT); 5. After, we initialize the serial monitor by indicating the number of baud (here 9600).

void loop(){ sensorValue=analogRead(sensorPin);

6. We define the sensorValue as being the value read by the Arduino.
 Serial.println("Soil Moisture Content : ");
 Serial.println(sensorValue);

7. We display the sensorValue on the serial monitor. if(sensorValue<limit){ digitalWrite(13, HIGH); } else{ digitalWrite(13, LOW); }

}

delay(1000);

4.1.3 Output

Soil Moisture Content :

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Soil Moisture Content :

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Soil Moisture Content :

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CHAPTER - V

APPLICATIONS OF SOIL MOISTURE SENSOR

5.1 Applications

1. Agriculture:

Measuring soil moisture is important for agricultural applications to help farmers manage their irrigation systems more efficiently. Knowing the exact soil moisture conditions on their fields, not only are farmers able to generally use less water to grow a crop, they are also able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

2. Landscape irrigation:

In urban and suburban areas, landscapes and residential lawns are using soil moisture sensors to interface with an irrigation controller. Connecting a soil moisture sensor to a simple irrigation clock will convert it into a "smart" irrigation controller that prevents irrigation cycles when the soil is already wet, e.g. following a recent rainfall event. Golf courses are using soil moisture sensors to increase the efficiency of their irrigation systems to prevent over-watering and leaching of fertilizers and other chemicals into the ground.

3. Research:

Soil moisture sensors are used in numerous research applications, e.g. in agricultural science and horticulture including irrigation planning, climate research, or environmental science including solute transport studies and as auxiliary sensors for soil respiration measurements.

4. Simple sensors for gardeners:

Relatively cheap and simple devices that do not require a power source are available for checking whether plants have sufficient moisture to thrive. After inserting a probe into the soil for approximately 60 seconds, a meter indicates if the soil is too dry, moist or wet for plants.

5. Research and Forecasting:

Beyond agriculture and plants, soil moisture sensors are used for research purposes. Collecting long-term soil moisture data can allow meteorologists and geologists to forecast or predict potential droughts, landslides, erosions, etc. Their analysis can then allow authorities to develop preventive measures before disasters strike.

6. Irrigation for Sporting Fields:

Be it American football, soccer or golf, they are all played on sporting fields that require irrigation to maintain. Soil moisture sensors ensure that such fields are well taken care of while avoiding over-irrigation.

7. Landslide Studies:

Changes in land use may increase the likelihood of landslides dangers. Each year, millions of dollars in damage to property and lives are lost due to landslides. Predicting and preventing landslide hazards is becoming very important in some urban areas. The inputs to landslide prediction models are slope, vegetation, toe slope, soil cohesiveness, and soil moisture. In some areas that experience perched water tables, the soil in the perched water table becomes very heavy as the soil becomes saturated thus becoming more influenced by gravity. Monitoring soil moisture is an important indicator for landslide hazards.

8. Dust Control

Poor air quality from particulates in air can have negative consequences to not only human health but regional ecosystems. Vehicular traffic on unpaved roads can lead to major dust problems. In areas of the Southwestern US, the soil is naturally abundant in several types of asbestos. Local officials close unpaved roads based on soil moisture conditions to prevent dangerous dust situations.

9. Drought Forecasting Models

Regional drought can severely affect the economy and even lead to starvation in some areas of the world. With advances in computer processing and environmental modeling methods, scientists are beginning to understand regional water budgets and hydrological processes. An important input into drought forecasting models is changes in regional soil moisture. Long-term soil moisture data over large regions can be used to predict and characterize harmful droughts.

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CHAPTER - VI CONCLUSION

6.1 Result

Soil sample was taken from the college campus. At first the Arduino UNO was programmed and then the soil moisture sensor was inserted into the dry soil first and then in the wet soil and now the moisture content in the dry soil and the wet soil is displayed in the output screen of the Arduino software.

6.2 Conclusion

The Arduino Program for measuring the soil moisture content through the soil moisture sensor is executed and the outputs are obtained on the screen. It can be seen that the moisture content varies for different types of soil i.e the moisture content value varies for dry soil and for wet soil. Thus the measurement of moisture content of the soil helps in growing of crops in the field of agriculture, Supports irrigation. By measuring the value of the moisture content we can come to know whether the soil is suitable for agriculture or not and also to predict the variety of crops that can be grown in the particular soil.

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GROWTH AND CHARACTERIZATION OF COPPER SULPHATE DOPED UREA AND MAGNESIUM SULPHATE SINGLE CRYSTALS

Project Report submitted to The Department Of Physics St.Mary's College (Autonomous), Thoothukudi. In partial fulfillment of the requirement for the award of

BACHELOR'S DEGREE IN PHYSICS

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S.Harishma	-19AUPH11
M.Muthu Valarmathi	-19AUPH26
B.Pushpa Lakshmi	-19AUPH33
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Guided By Dr. S. Euchrista Immaculate Sylvia



DEPARTMENT OF PHYSICS

ST.MARY'S COLLEGE (AUTONOMOUS) REACCREDITED WITH "A+" GRADE BY NAAC THOOTHUKUDI 2021-2022

CERTIFICATE

This is to certify that the project work entitled, "GROWTH AND CHARACTERIZATION OF COPPER SULPHATE DOPED UREA AND MAGNESIUM SULPHATE SINGLE CRYSTALS" is submitted to ST.MARY'S COLLEGE(AUTONOMOUS), THOOTHUKUDI in partial fulfillment for the award of Bachelor's

Degree in Physics and is a record of work done during the year 2021-2022 by the following students.

S.Harishma M.Muthu Valarmathi B.Pushpa Lakshmi S.Sakthi Priya M.A.Silviya S.Trinisha

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CHAPTER-1

INTRODUCTION TO CRYSTALS

"In a crystal we have a clear evidence of the existence of a formative life principle,and though we cannot understand the life of a crystal,it is nonetheless a living being."

-Nickola Tesla

1.1 INTRODUCTION:

'Growing good single crystals is an art.' The word crystal is derived from the ancient Greek word krustallos, meaning both "ice" and "rock crystal". Crystals are millions of years old, forged during the earliest parts of earth's formation.Crystal growth is a vital and fundamental part of material science and engineering, because crystals of suitable size and perfection are required for fundamental data acquisition and for practical devices such as detectors, integrated circuits and for other millions and millions of applications.Crystal growth is a great science project. It is almost an art rather than a pure science. Behind every new solid state device there stands a single crystal.[1]

Single crystal is a material in which the crystal lattice of the entire sample is continuous and unbroken to the edges of the sample, with no grain boundaries. A good quality of single crystal prerequiite for crystal structure determination by X-ray diffraction technique.Single crystal may be produced by the transport of crystal constituents in the solid, liquid or vapor phase.Water is a popular solvent for the growth of a variety of inorganic and organic compounds. A solvent can also play an indirect role in changing the morphology of the crystal. [17] This chapter discusses in detail various experimental techniques with its concept, mechanism and applications of a single crystal.

1.2 ABSTRACT:

To grow a crystal, the basic condition to be attained is the state of super saturation, followed by the process of nucleation. The information of super saturation and nucleation forms the basis of crystal growth. The growth of crystals from liquid and gaseous solutions, pure liquids and pure gases can only occur if some degree of super saturation or super cooling has been first achieved in the system. The attainment of the supersaturated state is essential for any crystallization operation and the degree of super saturation or deviation from the equilibrium saturated condition is the prime factor controlling the deposition process.

1.3 SOLIDS:



A solid is a state of matter with fixed shape and volume. Particles are closely-packed so they can vibrate, but not flow. Solids are rigid. They cannot be compressed easily. They are classified as

Crystalline solids

Single crystal:



It consists of only one crystal. Atoms are in a repeating or over the entire extent of the material.

Polycrystalline crystal:



Comprised of crystals or grains. Each crystal has periodic arrangement.

Amorphous solids

In amorphous solids, atoms are arranged in an irregular fashion. **Eg:** rubber, plastics and glass.

1.3.1 Crystalline solids:



Crystalline

A crystal or crystalline solid is a solid material whose constituents (such as atoms, molecules or ions) or arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions. **[8]** The smallest repeating structure of the solid is called a unit cell. Unit cell combine to form a network called crystal lattice.

1.3.1.1 Types of crystalline solids:

- **Covalent :** Are composed of atoms which are covalently bonded to one another.
- **Ionic:** Composed of alternating positive and negative ions.
- ✤ Metallic: Consists of metal cations surrounded by a "sea" of mobile valence electrons.
- **Molecular:** They are held together by weak intermolecular forces.

There are fourteen types of lattices called Bravais lattices and they are classified into seven crystals systems based on the arrangements.

Crystal	Lattice	Interfacial
System	Constants	Angles(Degree)
Cubic	a= b=c	α =β =√=90
Tetragonal	a = b≠ c	α =β =√=90
Orthorhombic	a≠b≠c	α =β =√=90
Monoclinic	a≠b≠c	α =β =90 ≠ √
Triclinic	a≠b≠c	α ≠ β ≠√ ≠90
Hexagonal	a=b≠c	α =β=90,
		√=120
Rhombohedral	a= b=c	α =β =√≠90

1.3.2 AMORPHOUS SOLIDS:



Amorphous

Any non crystalline solid in which the atoms and molecules are not organised in a definite lattice pattern. Such solids include glass, plastics and gel. [10] Amorphous solids are isotropic. The thermal and electrical conductivities, coefficient of thermal expansion and refractive index of an amorphous solid have the same value in whatever direction the properties are measured.

Amorphous solids, lacking the three-dimensional long-range order of a crystalline material, possess a more random arrangement of molecules, exhibit short-range order over a few molecular dimensions, and have physical properties quite different from those of their corresponding crystalline states.

1.4 APPLICATIONS OF CRYSTALS:

Solar Cells



One of the largest uses for crystals is in solar cells. Solar cells power various instruments from calculators to space vehicles. The solar cell produces energy, called photovoltaic energy, by using silicon.

Transistors



Made out of semi-conductors, which are based on the same types of materials and crystals as solar cells, transistors can regulate electron flow, detecting and amplifying radio signals and hence acting like digital "switches." Transistor radios, for example, make this use out of crystals.

Liquid Crystals

This precise substance made out of crystals can be used for a variety of different means, from heat and electricity to magnetism and mechanics. For example, wristwatches and some types of clocks use liquid crystals, as do some pocket calculators.

Spiritual Crystals



Amethyst crystals are thought to reduce feelings of anger and impatience. Other crystals uses include: aquamarine to release fear; carnelian to produce confidence; coral to intensify emotions: diamonds to increase prosperity; and sapphire to restore calm and a sense of balance.

Medicinal Crystals



Some new age medical practitioners claim that the presence and other uses of certain crystals promote different kinds of medical benefits. These benefits include: amethyst to treat headaches or unbalanced blood sugar; aquamarine to regulate the immune system, heart and lymph nodes; coral to help the metabolism, spine and tissue regeneration. [4]

1.5 NONLINEAR OPTICS AND NONLINEAR OPTICAL MATERIALS:

Nonlinear optics is given increasing attention due to its wide application in the area of laser technology, optical communication and data storage technology [6]. Nonlinear optics is completely, a new effect in which light of one wavelength is transformed to light of another wavelength. In an ordinary optical material, the electrons oscillate about their equilibrium position at the frequency of this electronic field. According to the fundamental law of physics, an oscillation change will radiate at its frequency of oscillation and hence these electrons in the crystal "generate" light at the frequency of the original light wave.

An NLO material is a compound in which a nonlinear polarization is invoked on application of an intense electric field. This electric field results from the external application of an intense laser-source. The nonlinear material is different from the linear material in several aspects. A nonlinear material is one, whose electrons are bound by very short springs.

At high fields, the polarization is proportional to the field and hence the susceptibility starts depending on the field. It is called **Non-linear Optics (NLO)** because, at high intensity, the graph representing the dependence of optical polarization on the light field amplitude has curvature and deviates from straight line.

One of the obvious requirements for a non-linear crystal is that it should have excellent optical quality. This means that for new materials, for which single crystal specimens are not available, it is necessary to grow single crystal specimens of optical quality. Thus in many cases the search for new and better non-linear optical materials is very largely a crystal growing effort.





1.5.1.1 ORGANIC NLO MATERIALS:

The first type, molecular materials, consists of chemically bonded moleculer units that interact in the bulk through weak Van der Waals interactions.For these materials the optical non-linearity is primarily derived from the molecular structure.The expression for the nonlinearity is highly dependent on the geometrical arrangement of the molecules in the case of second order nonlinear processes, but much less so for third order nonlinearities.The primary step in optimizing optical nonlinearities in this class of materials is at the molecular structural level, which then requires a detailed understanding of the relationship between molecular electronic structure and the nonlinear polarization that can be induced in a molecule.Organic materials have emerged during 1980's as an important class of nonlinear optical materials that offers unique opportunities for fundamentaly research as well as for technological applications.

Example: Urea,2-methyl-4-nitroaniline.

MERITS:

- 1. Optically more nonlinear
- 2. High optical damage threshold
- 3. Low cost
- 4. Broad spectral range

DEMERITS:

- 1. Poor mechanical strength
- 2. Poor thermal strength
- 3. Highly volatile

Difficulties in the Crystal Growth of Organic materials:

The principal limitation to the growth of large size, optically perfect crystals of organic nonlinear optical materials is that the solvent tends to be adsorbed on the highly polar growing surfaces. This blocks the growth and causes morphological instability which in turn leads to the formation of solvent inclusions in the growing crystal. Thermal instability is common with many organic materials. It is very difficult to obtain large size, well faced transparent organic single crystals. For fabrication of a SHG element, single crystal of at least minimum dimensions of 3 mm x 3 mm x 3mm is required. Fragile nature of organic crystal imposes difficulty in obtaining good quality crystals with less mechanical damage. The practical use of organic crystals in NLO devices as bulk crystals is limited due to their hygroscopic nature and difficulties in cutting and polishing. One of the best ways in preserving the hygroscopic crystals is to keep them immersed in index matching fluids.

1.5.1.2 INORGANIC NLO MATERIALS:

Nonlinearities in these materials are thought of arising from electron not associated with individual nuclei, such as in those metals and semiconductors. The optical non linearity in this class is determined by the electronic characteristics of the bulk medium and thus requires different theoretical frame works to account for this origins of nonlinear optical effects.

Examples of materials in these categories are: Quantum, well structures derived from GaAs, II-VI Semiconductors, and CdSe.

For inorganic systems important higher order nonlinear optical effects (eg: third order) are resonant (absorptive). Thus, heat dissipation tends to limit the cycle time of devices derived from these materials. Inorganic NLO materials are used in commercial applications but they also have drawbacks.

MERITS:

1) High electro optic co-efficient

2) High degree of chemical inertness

DEMERITS:

1) Poor optical quality

2) Difficulty to synthesis.Towards this direction, newer materials are currently being explored and this has led to a new class of NLO materials viz., Semiorganic.

1.6 SALTS: 1.6.1 MAGNESIUM SULPHATE:

Magnesium sulphate is a salt of magnesium with sulphuric acid. It is an anhydrous inorganic salt. The most common hydrate salt of Mg.SO4 is the Magnesium sulphate heptahydrate which has 7 molecules of water and has a formula $MgSO_4$. $7H_2O$. This salt is also known as Epsom salt. Magnesium sulphate is an excellent non linear optical (NLO) medium. Here magnesium sulphate is added with Copper sulphate to form a single crystal. [14]



Properties of Magnesium Sulphate:

•Magnesium sulphate is an anhydrous solid salt of white colour.

- It is an odourless salt.
- Magnesium sulphate salt is soluble in water.
- •Magnesium sulphate is not soluble in organic solvents like alcohol.
- •The molecular weight of magnesium sulphate is 120.366 g/mol.

1.6.2 UREA:

Urea, also called **carbamide**, the diamide of carbonic acid. Its formula is H_2NCONH_2 . It is a colourless, crystalline substance that melts at 132.7°C (271°F) and decomposes before boiling. Urea crystals fall under the category of organic materials exhibiting superior optical non-linear absorption coefficient. Urea is an non-linear optical medium. In recent years, various attempts have been made to synthesize organic and semi-organic urea & urea derivative single crystals. Here urea is added with Copper Sulphate to form a single crystal.



PROPERTIES OF UREA:

- It is colourless, crystalline solid. [13]
- It is highly soluble in water but less solution in alcohol.
- It is soluble in ether.
- Urea behaves as a mono acid base. It reacts with acids to form salts.
- It reacts with nitrous acid to form nitrogen, carbon dioxide & water.

1.7 COPPER SULPHATE:

Cupric sulfate is a salt created by treating cupricoxide with sulfuric acid. This forms as large, bright blue crystals containing five molecules of water ($CuSO_4.7H_2O$) and is also known as *blue vitriol*. The anhydrous salt is created by heating the hydrate to 150 °C (300 °F). Copper is an essential trace element and an important catalyst for heme synthesis and iron absorption. It is used as a colouring agent. It is used as a raw material in the preparation of other copper compounds, as a reagent in analytic chemistry, as an electrolyte for batteries.



1.8 ROLE OF IMPURITIES IN CRYSTAL GROWTH:

Impurities are present in all crystallization processes usually impurities are adventitious and undesirable but sometimes they are intentionally added and are called additives.Impurities change growth rates, shape and thickness of growth layers and growth habit, and are trapped as impurity striations and large clusters of impurities and inhomogeneities.Some of these effects are reviewed for growth of bulk single crystals **[5]**.The effect of impurities on the growth rate and habit of crystals growing in solution has been the subject of many experimental and theoretical studies over many years.Most of the impurities suppress growth, some impurities enhance it, while some others can stop growth completely even at the very low level of impurity concentration. The impurity effect depends on impurity concentration, supersaturation and temperature. Different impurities have different effects on the crystal growth, such as:

- Some may exert a highly selective effect, acting only on certain crystallographic faces.
- > Some are adsorbed onto growing crystal surfaces.
- > Some impurities may modify the habit of the crystalline phase.

1.9 MAIN OBJECTIVES OF THE PROJECT WORK:

In this project work, growth of Copper Sulphate doped Urea and Magnesium sulphate single crystals were carried out by employing slow evaporation solution method and various properties of the grown crystals were studied. It is aimed at

- Growing Copper Sulphate added Urea and Magnesium sulphate crystals by Slow Evaporation Solution Technique (SEST) at room temperature.
- ✤ Identifying the size of the particle by powder X-ray diffraction analysis (PXRD).
- Studying the incorporation of the dopant in Urea and Magnesium sulphate crystals by UV-visible spectral analysis.
- Finding the functional groups present in the grown crystals by Fourier Transform Infrared (FTIR) analysis.



CHAPTER-2

CRYSTAL GROWTH METHODS

2.1 BASICS OF CRYSTAL GROWTH:

To grow a crystal, the basic condition to be attained is the state of super saturation, followed by the process of nucleation. The information of super saturation and nucleation forms the basis of crystal growth. The growth of crystals from liquid and gaseous solutions, pure liquids and pure gases can only occur if some degree of super saturation or super cooling has been first achieved in the system. The attainment of the supersaturated state is essential for any crystallization operation and the degree of super saturation or deviation from the equilibrium saturated condition is the prime factor controlling the deposition process.

In general, the crystallization process takes place by three steps:

- Achievement of super saturation or super cooling.
- Formation of crystal nuclei.
- Growth of crystal. [7]

2.2 NUCLEATION:

Nucleation is an important phenomenon in crystal growth and is the pre-cursor of crystal growth and of the overall crystallization process. The condition of super saturation alone is not sufficient cause for a system to begin crystallization. Before crystals can grow, there must exist in the solution a number of minute solid bodies known as centers of crystallization, seeds, embryos or (nuclei). The formation of stable nuclei occurs only by the addition of a number of molecules (A1) until a critical cluster is formed. In general,

A(n-1) + A1 = An (critical)

Once these nuclei grow beyond a certain critical size, they become stable under the average condition of super saturation of the solution.



Nucleation may occur spontaneously or it may be induced artificially and they are usually referred to as homogeneous and heterogeneous nucleation respectively. The term primary is used for both homogeneous and heterogeneous nucleation even in systems that do not contain crystalline matter. On the other hand, during secondary nucleation, nuclei are often generated in the vicinity of the crystals present in the supersaturated system. This process involves the dislodgement of the nuclei from the parent crystal at super saturation in which primary homogeneous nucleation cannot occur. When a supersaturated solution is disturbed by agitation, friction or mechanical stimulus in the presence of the crystalline substance of the solute, embryos are formed at the surfaces of the parent crystal. These embryos give rise to secondary nucleation.

If the nuclei form homogeneously in the interior of the phase, it is called homogeneous nucleation. If the nuclei form heterogeneously around ions, impurity molecules or on dust particles, on surfaces or at structural singularities such as imperfections or dislocations, it is known as heterogeneous nucleation. [2]

2.3 METHODS OF CRYSTAL GROWTH:

Crystal growth is a challenging task and the technique followed for crystal growth depends upon the characteristics of the materials under investigation such as its melting point, volatile nature, solubility in water or other organic solvents and so on. [3] The basic growth methods available for crystal growth are

- Growth from melt
- ✤ Growth from vapour
- ✤ Growth from solution
- ✤ Growth from solid


2.3.1 GROWTH FROM THE MELT:

Melt growth is the process of crystallization of fusion and resolidification of the pure material, crystallization from a melt on cooling the liquid below its freezing point. In this technique apart from possible contamination from crucible materials and surrounding atmosphere, no impurities are introduced in the growth process and the rate or growth is normally much higher than possible by other methods. Melt growth is commercially the most important method of crystal growth. The growth from melt can further be sub-grouped into various techniques.

- Bridgmann method
- Czochralski method
- Vernuil method
- Zone melting method
- Kyropoulos technique
- ➢ Skull melting

BRIDGEMANN METHOD:

This technique was named after its inventor Bridgemann in 1925, Stockbarger in1938. The Bridgmann technique is a method of growing single crystal ingots or boules. The method involves heating polycrystalline material in a container above its melting point and slowly cooling it from one end where a seed crystal is located. Single crystal material is progressively formed along the length of the container, the process can be carried out in a horizontal or vertical geometry.



ADVANTAGE:

- This method is technically simple.
- This technique is low cost.
- Selecting the appropriate container can produce crystal of pre assigned diameter.

DISADVANTAGE:



The compression of the solid by the contracting container during cooling can

lead to the development of stresses high enough to nucleate dislocations in the

This method is widely used for growing semi conducting material crystal. The shape of the crystal is free from the constraint due to the shape of the crucible. In this method the charge is melted and maintained at a temperature slightly above the melting point. The pulling rod is lowered to just touch the melt. Since the rod is at lower temperature of melt occurs at the point tip of the pulling rod. The crystal is pulled slowly. The rate of pulling upon various factors like thermal conductivity, latent heat of fusion of charge and rate of cooling of the pulling rod. The seed is rotated to keep the grow crystal uniform and cylindrical.

ADVANTAGE:

- This method is used to grow large single crystals. Thus it is used extensively in the semiconductor industry.
- There is no direct contact between the crucible walls and the crystal which helps to produce unstressed single crystal.

DISADVANTAGE:

In general this method is not suitable for incongruently melting compounds and of course the need for a seed crystal of the same composition limits is used as tool for exploratory synthetic research.

VERNUIL METHOD:

Chemically pure fine powder which emerges through an Oxygen-hydrogen flame and falls onto the fused end of an oriented single crystal seed fixed to a lowering mechanism. The powder charge is fed from bankeei by mean of a special tapping mechanism. Coordinating the consumption of the charge, hydrogen and oxygen with the rate of descent of the seed ensures crystallization at a prescribed level of the apparatus.



ADVANTAGE:

- There is no container which eliminates the problem of physical-chemical interaction between the melt and the container material.
- ✤ It is technically simple and the growth of crystal can be observed.

ZONE MELTING METHOD:

In this technique a liquid zone is created by melting a small amount of materials in a relatively large or long solid charge. Zone melting techniques basically enable one to manipulate distribution of soluble impurities or phases through a solid.



ADVANTAGE:

- Zone melting technique is that impurities tend to be concentrated in the melted portion of the sample.
- The process sweeps them out of the sample and concentrates them at the end of the crystal bowl, which is then cut off and discarded. Thus this method is sometimes used to purify semiconductor crystals.

KYROPOULOS TECHNIQUE:



In this technique, a cooled seed to initiate single crystal growth within the melt containing crucible. Heat removal continues by controlling the furnace temperature to grow the crystal.

ADVANTAGE:

- The crystal is grown in a larger diameter.
- ✤ With the large diameter crystal we can make prisms, lenses and other optical components.

SKULL MELTING PROCESS:



Skull melting process is used for the growth of high melting point materials. Cubic zirconium is made using a radio-frequency "Skull crucible" system, a specialized melt process. This is a type of super-hot melt process used to produce the most widely accepted diamond imitation: Cubic zirconia(cz). Conventional (low) melt crucibles cannot be used. Therefore a crucible free technique is inevitable. The Skull melting process is used to produce Zirconia up to 10 cm long.

ADVANTAGES:

The process is crucibleless, a thin skull separates the molten mass from the water-cooled container. Thus, contamination problems or exsolution processes associated with contact between melts and hot crucibles are avoided. Single crystals of considerable size and perfection may readily be grown in copious quantities. [18]

2.3.2 GROWTH FROM VAPOUR:

VAPOUR GROWTH:

Crystallization from Vapour is widely adopted to grow bulk crystal, epitaxial films, and thin coatings. Techniques for growing crystals from vapour is divided into two types they are,

- ✤ Chemical transport method
- Physical transport method

CHEMICAL TRANSPORT METHOD:



This method involves a chemical transport in which material is transported as a chemical compound (halide), which decomposes in the growth area. In this case depending on the nature of the reaction involved. The growth region may be either hotter or cooler than the source.

PHYSICAL TRANSPORT METHOD:



This method involves in the direct transport of materials by evaporation or sublimation from a hot source zone to a cool region II-VI compounds (Zns, Cds) are widely grown by this method either in vaccum or with a moving gas stream. In both cases the growth can be suitable with seed crystals, which can either be of the material being grown or some other material with similar lattice spacing. In this case the substance evaporates and diffuses from hot end to a cooler growth end. In then, deposits in the form of single crystals.

ADVANTAGES:

- Films can obtain by the close spaced transport method and decomposition of compounds.
- Crystal of silicon, diamond, gas, semiconductor compounds can be grown by this method.

2.3.3 GROWTH FROM SOLUTION:

In this method, Crystals are grown from aqueous solution. This method is also widely practiced for producing bulk crystals. The four major types are

- ✤ Low temperature solution growth
- High temperature solution growth
- Hydro Thermal growth
- ✤ Gel Growth

LOW TEMPERATURE SOLUTION GROWTH:

This is a widely practiced method. The techniques used here are,

- Slow cooling method
- Solvent Evaporation method
- Temperature Gradient method

SLOW COOLING METHOD:

A saturated solution above the room temperature is poured in a crystallizer and thermally sealed. A seed crystal is suspended in the solution and the crystallizer is kept in a water thermostat, whose temperature is reducing according to a pre assigned plan, which results in the formation of large single crystals. The need to use a range of temperature is the origin of 5751 disadvantages. The possible range is usually small so that much of the solute remains in the solution at the end of run. To compensate for this effect, large volumes of solution are needed.



SLOW EVAPORATION METHOD:



This method is similar to the slow cooling method in view of the apparatus requirements. The temperature is fixed constant and provision is made for evaporation. With non-toxic solvents like water, it is permissible to allow evaporation into the atmosphere. Typical growth conditions involve temperature stabilization to about $\pm 0.005^{\circ}$ C and rates of evaporation of a few ml/hr. The evaporation techniques of crystal growth have the advantage that the crystals grow at a fixed temperature. But inadequacies of the temperature control system still have a major effect on the growth rate. This method is the only one, which can be used with materials, which have very small temperature coefficient of stability. [15]

TEMPERATURE GRADIENT METHOD:



This method involves the transport of the materials from a hot region containing the source material to be grown to a cooler region where the solution is supersaturated and the crystal grows. The main advantages of this method are:

- > Crystal grows at a fixed temperature.
- > This method is insensitive to changes in temperature provided both the source and the growing crystal undergo the same change.
- Economy of solvent and solute.

On the other hand, changes in the small temperature differences between the source and the crystal zones have a large effect on the growth rate.

Excellent quality crystals of ferroelectric and piezo-electric materials such as Ammonium dihydrogen phosphate (ADP), Potassium dihydrogen phosphate (KDP) and Triglycine sulphate (TGS) are commercially grown for use in devices by the low temperature solution growth method. Growth of crystal ranges from a small inexpensive technique to a complex sophisticated expensive process and crystallization time ranges from minutes, hours, days and to months. Single crystals may be produced by the transport of crystal constituents in the solid, liquid or vapour phase.

On the basis of this, crystal growth may be classified into three categories as follows,

- Solid Growth Solid-to-Solid phase transformation
- Liquid Growth Liquid to Solid phase transformation
- ✤ Vapour Growth Vapour to Solid phase transformation

CHAPTER III



CHAPTER 3

CHARACTERISATION TECHNIQUES

3.1 INTRODUCTION:

Characterisation techniques include SEM(scanning electron microscopy), TEM (transmission electron microscopy), X-ray diffraction, UV studies,FTIR, XRD, X-ray fluorescence, NMR (nuclear magnetic resonance) and synchrotron techniques.

3.2 X-RAY DIFFRACTION:

XRD is a technique employed to determine the underlying crystal structure of a material; it enables verification of the crystallinity and structure of a sample but gives no information of a chemical nature. Fitting XRD patterns can allow calculation of the material lattice parameters, the orientation of a crystal, stress in crystalline regions, and secondary phases in the sample. It is generally a bulk characterization technique and produces an average diffraction pattern for the area measured. XRD is a non destructive technique which can be conducted at room temperature and pressure. [12]

Since most materials have unique diffraction patterns, compounds can be identified by using a database of diffraction patterns. The purity of a sample can also be determined from its diffraction pattern, as well as the composition of any impurities present. A diffraction pattern can also be used to determine and refine the lattice parameters of a crystal structure. A theoretical structure can also be refined using a method known as Rietveld refinement. The particle size of the powder can also be determined by the powder can also be determined by using the Scherrer formula, which relates the particle size to the peak width .

3.2.1 POWDER X-RAY DIFFRACTION ANALYSIS:



The analytical technique PXRD is used to determine the crystallinity degree or amorphization of the examined samples.

In this technique ,sample preparation is not necessary and,unlike other techniques, the sample does not change physiochemically after finishing the technique. The methods used vary according to the material of analysis and equipment used. The parameters used are typically 40-45 kV and 30-40 mA.



XRD or X- ray powder d+iffraction is an analytical technique widely used in phase identification of crystalline structures and to determine the atomic spacing.Crystalline structures act as a three dimensional diffraction grating for X-ray. In the XRD machine, a cathode ray tube generates the X-ray then the X-ray is filtered to produce monochromatic radiation and then collimated to hit the sample. The beam then produces a constructive interference when it satisfies the Bragg's Law. For the powdered sample, the beam scans through a 2θ angle to cover all possible angles of the sample. The diffracted beam is then processed to identify the material as every crystal has a set of unique spacing.

3.2.2 FUNDAMENTALS OF X-RAY POWDER DIFFRACTION:

X-ray diffractometers consist of three basic elements: an X-ray tube, a sample holder, and an X-ray detector. X-rays are generated in a cathode ray tube by heating a filament to produce electrons, accelerating the electrons toward a target by applying a voltage, and bombarding the target material with electrons. When electrons have sufficient energy to dislodge inner shell electrons of the target material, characteristic X-ray spectra are produced. These spectra consist of several components, the most common being K α and K β . K α consists, in part, of K α_1 and $K\alpha_2$. $K\alpha_1$ has a slightly shorter wavelength and twice the intensity as $K\alpha_2$. The specific wavelengths are characteristic of the target material (Cu, Fe, Mo, Cr). Filtering, by foils or crystal monochrometers, is required to produce monochromatic X-rays needed for diffraction. K α_1 and K α_2 are sufficiently close in wavelength such that a weighted average of the two is used. Copper is the most common target material for single-crystal diffraction. These X-rays are collimated and directed onto the sample. As the sample and detector are rotated, the intensity of the reflected X-rays is recorded. When the geometry of the incident X-rays impinging the sample satisfies the Bragg Equation, constructive interference occurs and a peak in intensity occurs. A detector records and processes this X-ray signal and converts the signal to a count rate which is the output to a device such as a printer or computer monitor.

The geometry of an X-ray diffractometer is such that the sample rotates in the path of the collimated X-ray beam at an angle θ while the X-ray detector is mounted on an arm to collect the diffracted X-rays and rotates at an angle of 2 θ . The instrument used to maintain the angle and rotate the sample is termed a goniometer. For typical powder patterns, data is collected at 2 θ from ~5° to 70°, angles that are preset in the X-ray scan.[11]

3.3 ULTRAVIOLET VISIBLE SPECTROSCOPY:

UV spectroscopy or UV-visible spectrophotometry (UV-Vis or UV/Vis) refers to absorption spectroscopy or reflectance spectroscopy in part of the ultraviolet and the full,adjacent visible regions of the electromagnetic spectrum.Ultraviolet-visible (UV-Vis) spectrophotometry is a technique used to measure light absorbance across the ultraviolet and visible ranges of the electromagnetic spectrum. When incident light strikes matter it can either be absorbed, reflected, or transmitted. The absorbance of radiation in the UV-Vis range causes atomic excitation, which refers to the transition of molecules from a low - energy ground state to an excited state.



3.3.1 WAVELEGTH:

Monochromators - A Monochromator separates light into a narrow band of wavelengths. It is most often based on diffraction gratings that can be rotated to choose incoming and reflected angles to select the desired wavelength of light. The diffraction grating's groove frequency is often measured as the number of grooves per mm. A higher groove frequency provides a better optical resolution but a narrower usable wavelength range. A lower groove frequency provides a larger usable wavelength range but a worse optical resolution. 300 to 2000 grooves per mm is usable for UV-Vis spectroscopy purposes but a minimum of 1200 grooves per mm is typical. The quality of the spectroscopic measurements is sensitive to physical imperfections in the diffraction grating and in the optical setup.

- ✤ Absorption filters Absorption filters are commonly made of colored glass or plastic designed to absorb particular wavelengths of light.
- Interference filters Also called dichroic filters, these commonly used filters are made of many layers of dielectric material where interference occurs between the thin layers of materials. These filters can be used to eliminate undesirable wavelengths by destructive interference, thus acting as a wavelength selector.
- Cutoff filters Cutoff filters allow light either below (short pass) or above (long pass) a certain wavelength to pass through. These are commonly implemented using interference filters.
- Band pass filters -Band pass filters allow a range of wavelengths to pass through that can be implemented by combining short pass and long pass filters together.

3.3.2 APPLICATION OF UV VISIBLE SPECTROSCOPY:

- ➤ UV absorption spectroscopy is used to determine the dissociation constants of acids and bases.
- ➤ UV absorption spectroscopy is generally used for the qualitative determination of compounds that absorb UV. □
- ➤ UV absorption spectroscopy is one of the best methods for defecting impurities in organic compounds.
- ➤ UV absorption spectroscopy can characterize those type of compounds whiz absorb UV radiation.
- > UV absorption spectroscopy can be used to study the kinetics of reaction.[18]



If the sample compound does not absorb light of a given wavelength, $I=I_0$. However, if the sample compound absorbs light then I is less than I_0 , and this difference may be plotted on a graph versus wavelength, as shown on the right. Absorption may be presented as transmittance ($T = I/I_0$) or absorbance ($A = \log I_0/I$). If no absorption has occurred, T = 1.0 and A = 0. Most spectrometers display absorbance on the vertical axis, and the commonly observed range is from 0 (100% transmittance) to 2 (1% transmittance). The wavelength of maximum absorbance is a characteristic value, designated as λ_{max} .

Different compounds may have very different absorption maxima and absorbances. Intensely absorbing compounds must be examined in dilute solution, so that significant light energy is received by the detector, and this requires the use of completely transparent (non-absorbing) solvent. The most commonly used solvents are water, ethanol, hexane and cyclohexane. Solvents having double or triple bonds, or heavy atoms (e.g. S, Br & I) are generally avoided. Because the absorbance of a sample will be proportional to its molar concentration in the sample c known as the molar absorptivity is used when comparing the spectra of different compounds.uvette, a corrected absorption value.

This is defined as:

Molar Absorptivity = A/ c l

where A = absorbance,

c = sample concentration in moles/liter &

l = length of light path through the cuvette in cm.[19]

3.4 FOURIER TRANSFORM INFRARED SPECTROSCOPY:

Fourier Transform Infrared Spectroscopy (FTIR) is a powerful tool for identifying types of chemical bonds in a molecule by producing an Infrared absorption spectrum that like a molecular "finger print" Fourier Transform Infrared Spectroscopy (FTIR) is an analytical technique used to identify organic (and in some cases inorganic) materials. This technique measures the absorption of various infrared light wave lengths by the material of interest. These Infrared absorption bands identify specific molecular component and structures.



3.4.1 WORKING FOR FTIR PROCESS:

The normal instrumental process is as follows: \Box

The Source: Infrared energy is emitted from a glowing black-body source. This beam passes through an aperture which controls the amount of energy presented to the sample (and, ultimately, to the detector). \Box

The Interferometer: The beam enters the interferometer where the "spectral encoding" takes place. The resulting interferometer signal then exits the interferometer.

The Sample: The beam enters the sample compartment where it is transmitted through or reflected off the surface of the sample, depending on the type of analysis being accomplished. This is where specific frequencies of energy, which are uniquely characteristic of the sample, are aborted.

The Detector: The beam finally passes to the detector to final measurement. The Detectors used are specially designed to measure the special interfero-gram signal.

Advantages of FT-IR:

- Speed: All of the frequencies are measured simultaneously, most measurement by FT-IR are made in a matter of seconds rather than several minutes.
- Sensitivity: It is dramatically improved with FT-IR for many reasons. The detectors employed are much more sensitive, the optical throughput is much higher results in much lower noise levels.
- Mechanical Simplicity: The moving mirror in the interferometer is the only continuously moving part in the instrument. Thus there is very little possibility of mechanical breakdown.

FT-IR technique has brought significant practical advantages to infrared spectroscopy. It has possible the development of many new sampling techniques which were designed to tackle challenging problems which were impossible by order technology. It has made the use of infrared analysis virtually limitless.

Application of FTIR:

It can identify unknown materials. \Box

- ✤ It can identify variation.
- It can determine the quality of example.
- It can determine the amount of component in a mixture.FTIR is much more sensitive.

3.4.2 WHERE IS FTIR SPECTROSCOPY USED FOR?

FTIR spectroscopy is used in organic synthesis, polymer science, petrochemical engineering, pharmaceutical industry and food analysis. In other words, it has a wide array of applications, from monitoring processes to identifying compounds to determining components in a mixture.

HOW DOES FTIR WORK?

A molecule's covalent bonds will selectively absorb radiation of specific wavelengths, which changes the vibrational energy in the bond. The type of vibration (stretching or bending) induced by the infrared radiation depends on the atoms in the bond. Because different bonds and functional groups absorb different frequencies, the transmittance pattern is different for different molecules. (Transmittance is the flip side of absorbance). The spectrum is recorded on a graph with wave number (cm^{-1}) recorded on the X-axis and transmittance recorded on the Y-axis. (Wave number is 1/wavelength and corresponds to the energy of the vibration of the molecular bonds).

3.4.3 HOW TO READ AN FTIR SPECTRUM?

Reading the spectrum is a matter of determining which groups and bonds correspond to which peaks.

- ➤ The X-Axis: The Infrared Spectrum. The x-axis-or horizontal axis-represents the infrared spectrum, which plots the intensity of infrared spectra.
- > The Y-Axis: Absorbance or Frequency.
- > The Absorbance Bands.





CHAPTER-4

RESULTS AND DISCUSSION

4.1 INTRODUCTION:

This chapter deals with the growth of CuSO₄ doped Urea and MgSO₄ by slow evaporation solution technique and characterization of the grown crystals. The results obtain from XRD analysis, FTIR spectral analysis and UV studies are reported and discussed in this chapter.

4.2 EXPERIMENTAL PROCEDURE:

Growth of CuSO₄ doped Urea and MgSO₄ :

Growth of CuSO₄ doped Urea and MgSO₄ were grown by slow evaporation solution technique at room temperature. Saturated solution was prepared by mixing the salt with demineralised water. To obtain homogeneous solution it was stirred using magnetic stirrer for about two hours. Then the saturated solution was filtered using whatman filter paper. The filtered solution was then transferred to separate borosil glass beaker covered with porous paper with controlled evaporation. The good quality doped crystals were harvested within a period of 10-15 days. The experimental set up is in the figure: 4.2.1a and 4.2.1b. Grown single crystals are photographed and shown in the figure: 4.2.2a and 4.2.2b



Figure 4.2.1a Experimental set up

Photograph of CuSO₄ doped

[31]

Urea crystal

Figure: 4.2.2a



Figure 4.2.1b Experimental set up





4.3 POWDER X-RAY DIFFRACTION ANALYSIS:

The grown crystals have been crushed into uniform fine powder and subjected to powder X-ray diffraction to identify the reflection planes. Advanced PAN analytical XPERT PRO diffractrometer was used to record the diffraction pattern of the grown sample with CuK α (λ =1.54056 Å). The sample was scanned over the required 2 θ range of 10°- 30°. X-ray diffraction data gives the angle of scattering (2 θ) and the corresponding intensities of diffracted beam for each reflection. All the reflections of powder XRD pattern of the grown crystals were indexed using INDEXING software package following of the procedure of C.Lipson and Steeple(1970). Indexing of the powder pattern consists of assignment of the numbers h,k,l (miller indices) to each reflection. The indexed powder X-ray diffraction pattern of the grown crystals are shown in figure: 4.3.1 and 4.3.2.The occurrence of sharp peaks at specific Bragg's angles gives surety of high crystallinity of Urea and MgSO₄ doped with CuSO₄.

Figure: 4.3.1 shows the X-ray diffraction pattern of CuSO₄ doped MgSO₄. The diffraction pattern shows sharp deflection corresponding to orthorhombic structure. The Powder XRD pattern from the grown crystals with high intensity peaks were observed at

 2θ = 16.6700 along the (210) h, k, l plane θ = 19.8112 along the (121) h, k, l plane θ = 21.1803 along the (211) h, k, l plane θ = 33.7610 along the (312) h, k, l plane

From the above observation it is understood that the doped crystal exhibits orthorhombic structure as confirmed from the JCPDS file: 75-0673. The absence of impurities peak reveals that the grown crystals exhibit high crystalline quality. Using β as Full Width at Half Maximum (FWHM) of a broad diffraction peak, average grain size is estimated by applying the

Scherrer's equation: $D = K\lambda/\beta \cos \theta$ Where K= 0.9 (Scherrer's constant) λ is X-ray wavelength θ is Diffracted angle β is Full Width at Half Maximum(FWHM)

The average particle size obtained from XRD data is found to be 79.10 nm

Figure:4.3.1 POWDER XRD PATTERN FOR CuSO₄ DOPED MgSO₄



Table:4.3.1a	Powder XRD	data for	CuSO ₄	doped MgSO ₄
--------------	------------	----------	-------------------	-------------------------

S.NO	2θ degree	d-spacing Å	h k l
1.	16.6700	5.3121	210
2.	19.8112	4.476	121
3.	21.1803	4.1904	211
4.	33.7610	2.6517	312

Table:4.3.1b Crystallographic data (PXRD) for CuSO₄ doped MgSO₄

CRYSTAL PARAMETERS	CuSO ₄ DOPED MgSO ₄
a (Å)	15.261 (Å)
b (Å)	22.68 (Å)
c (Å)	5.143 (Å)
System	Orthorhombic

Figure: 4.3.2 shows the X-ray diffraction pattern of CuSO₄ doped Urea. The diffraction pattern shows sharp deflection corresponding to tetragonal structure. The Powder XRD pattern from the grown crystals with high intensity peaks were observed at

 2θ = 22.66 along the (110) h, k, l plane θ = 24.68 along the (101) h, k, l plane θ = 29.45 along the (111) h, k, l plane θ = 31.83 along the (200) h, k, l plane θ = 35.74 along the (201) h, k, l plane θ = 37.41 along the (002) h, k, l plane θ = 54.02 along the (311) h, k, l plane

From the above observation it is understood that the doped crystal exhibits tetragonal structure as confirmed from the JCPDS file: 31-1979. The absence of impurities peak reveals that the grown crystals exhibit high crystalline quality. Using β as Full Width at Half Maximum(FWHM) of a broad diffraction peak, average grain size was estimated by applying the Scherrer's equation and is reported to be 42.12 nm.

Figure:4.3.2 POWDER XRD PATTERN FOR CuSO₄ DOPED UREA



Table:4.3.2aPowder XRD data for CuSO4 doped Urea

S.No	2θ (degree)	d-spacing (A°)	hkl
1.	22.66	3.9205	1 1 0
2.	24.68	3.6031	1 0 1
3.	29.45	3.0297	1 1 1
4.	31.83	2.8081	2 0 0
5.	35.74	2.5097	2 0 1
6.	37.41	2.4013	0 0 2
7.	54.02	1.6956	3 1 1

Table:4.3.2b Crystallographic data (PXRD) for CuSO₄ doped Urea

1
CuSO4 DOPED UREA
5.544 (Å)
5.544 (Å)
5.918 (Å)
Tetragonal

4.4 UV SPECTRA OF COPPER SULPHATE DOPED MAGNESIUM SULPHATE AND UREA

UV spectra was recorded using a Shimadzu double beam spectrometer in the wavelength 200nm- 800 nm. λ_{max} for CuSO₄ appears at 635 nm as per reported literature and reported UV spectra of urea is also shown below. It can be observed that copper sulphate doped urea (Fig:4.4.1) shows a peak at 779 nm thereby clearly indicating the insertion of CuSO₄ in the lattice sites. In the case of copper sulphate doped magnesium sulphate (Fig:4.4.2) characteristic peak for copper is not observed probably that the copper has not been adsorbed into the lattice sites.



Fig:4.4.2 UV Spectra of Copper sulphate doped Magnesium sulphate

4.5 FTIR SPECTRA OF COPPER SULPHATE DOPED MAGNESIUM SULPHATE AND UREA

FTIR spectrum of reported MgSO₄.7H₂O shows characteristic O-H stretching band at 3271.27 cm^{-1} and O-H bending vibrational band at 1647.21 cm^{-1} .The absorption band at 1064.71 cm^{-1} corresponds to SO₄⁻² stretching vibration, and the band at 981.77 cm^{-1} is due to SO₄⁻² bending vibration. The bands at 661.85 cm^{-1} and 605.65 cm^{-1} is attributed MgO group.

The infrared spectrum of CuSO₄·5H₂O shows peaks at 3420 cm^{-1} and 1667 cm^{-1} assigned for O-H stretching and bending modes, respectively, for copper sulfate pentahydrate.

In the case of urea N-H stretching occurs at around 3500 cm^{-1} , C=O around 1750 cm^{-1} , N-H deformation at around 1600 cm^{-1} and C-N around 1400 cm^{-1} . In copper sulphate doped urea Fig:4.5.1 additional peaks arise at 3446 cm^{-1} corresponding to O-H stretching mode of water in copper sulphate pentahydrate, one at 1679 cm^{-1} due to O-H bending in copper sulphate pentahydrate 2470 cm^{-1} which is a clear indication that CuSO₄ is adsorbed into the lattice sites.

Similarly in copper sulphate doped magnesium sulphate Fig:4.5.2 there are not much changes in the stretching indicating the absence of incorporation of copper sulphate.





CHAPTER-5

CONCLUSION

This project work was aimed to grow CuSO₄ doped Urea and Magnesium sulphate crystals and to characterize the grown crystals by various studies. The following conclusions are drawn from the results of the studies.

- CuSO₄ doped Urea and Magnesium sulphate were grown by slow evaporation solution technique at room temperature. The crystal is found to be stable and of good quality.
- The grown crystals were subjected to powder XRD analysis and all the prominent peaks were indexed. From the experimental data, it is observed that the doped Urea belongs to tetragonal system and doped Magnesium sulphate belongs to orthorhombic system.Crystal parameters and average grain size of the particle were also determined.
- The UV-visible transmission analysis and Fourier Transform Infrared (FTIR) analysis were also done. Additional peaks were observed in CuSO₄ doped Urea showing the presence of incorporation of Copper whereas, it was observed in both UV and FTIR analysis the absence of incorporation of Copper in CuSO₄ doped MgSO₄.



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TERRAIN ANALYSIS, 3D DEM VISUALIZATION AND CREATION OF COVID-19 MAP

Project report submitted to the Department of Physics

ST. MARY'S COLLEGE (AUTONOMOUS)

THOOTHUKUDI

Affiliated to MANONMANIUM SUNDARANAR UNIVERSITY, TIRUNELVELI

In partial fulfillment of the requirement for the award of BACHELOR'S DEGREE IN PHYSICS

BY

DHIVYA DHARSHINI. D	19AUPH08	
JAFFRY. T	19AUPH12	
MARIA JOCELIN SHELCIA. M	19AUPH23	
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Under the guidance of

Ms. A. Lucas Rexceline M.Sc., M.Ed., M.Phil.



Department of Physics

ST. MARY'S COLLEGE (AUTONOMOUS)

Reaccredited with "A⁺" Grade by NAAC

Thoothukudi

2021-2022

CERTIFICATE

This is to certify that this project work entitled "TERRAIN ANALYSIS, 3D DEM VISUALIZATION AND CREATION OF COVID-19 MAP" is submitted to ST. MARY'S COLLEGE (AUTONOMOUS), THOOTHUKUDI in partial fulfillment for the award of Bachelor's degree in Physics and is a record of work done during the year 2021-2022 by the following students.

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A STUDY OF TERRAIN ANALYSIS AND 3D MODELLING OF THOOTHUKUDI

Project report submitted to the Department of Physics

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"It is not possible to prepare a project report without the assistance and encouragement of the other people. This one is certainly no exception."

On the very outset of this report, we would thank God for being able to complete this project with success.

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Any omission in this brief acknowledgement does not mean lack of gratitude.

ABSTRACT

The 3D modeling is one of the crucial topics that are still under analysis by many engineers and programmers because of the great advancements in data acquisition technologies and 3D computer graphics programming. To achieve that goal, the city Thoothukudi, located in Tamilnadu was chosen as a case study. The minimum data requirements to generate a 3D city model are the terrain, 2D spatial features such as buildings, landscape area and street networks. Moreover, building height is an important attribute in the 3D extrusion process. First, the terrain was obtained from a Digital Elevation Model (DEM). Second, 2D data were obtained. To present terrain characteristics of Thoothukudi especially relief zoning, aspect analysis, hill shade view, slope, sieve etc... Covid 19 pandemic in India statistics is simulated as an application of terrain analysis on the generated 3D city model. It is reported that, this study is very valuable in mapping and computing the total Covid 19 cases in the city.

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1. INTRODUCTION:

Terrain Analysis is the analysis and interpretation of topographic features through geographic information systems. Such features include slope, aspect, view shed, elevation, contour lines, flow lines, up slope flow lines and down slope flow lines. It is the study of the nature, origin, morphological history and composition of land forms, the result of which is a land form or land component map. It employs elevation data, usually in conjunction with other geospatial information, to describe the landscape, for basic visualization, modeling, or to support decision making. The collection, analysis, evaluation, and interpretation of geographic information on the natural and manmade features of the terrain, combined with other relevant factors, to predict the effect of the terrain on military operations. The terrain of a region largely determines its suitability for human settlement.

The intention is to build mathematical abstraction of surface terrain in order to delineate or stratify landscapes and create an understanding of relationships between ecological processes and physical features.

Geographic information systems (GIS) applications are moving towards 3D, as it has the capacity to better represent the real world. Currently most of these applications can be run in online environments. The emerging of geo-browsers such as Google Earth, Microsoft Virtual Earth, and World Win, made the demands for these kinds of applications increase tremendously. 3D terrain visualization is a most important part of this technology. They require both the terrain rendering and the geo-spatial data visualization to identify and analyze important features in the data. Features refer to subsets of data that are of particular interest, such as certain mountainous structures, specific weather conditions, or objects of interest. It is important to effectively communicate these features and, therefore, customized presentations are required. The digital elevation model (DEM), an important source of information, is usually used to express a topographic surface in three dimensions and to imitate essential natural geography.



Applications of QGIS provide opportunities for modeling, analyzing and displaying geographical phenomena connected with topography and relief. The utility of the DEM is evidenced by the widespread availability of digital topographic data and ever- increasing applications of DEM. They have been found useful in many fields of study such as terrain analysis. Terrain and slope analysis, globally, are used for demarcating sites of sedimentation, stable zones, etc., which ultimately provide important data to develop final remedy structures and to deliver solutions for various environmental problems. DEMs are being used for a wide variety of scientific and commercial purposes.
2. LITERATURE REVIEW

Bi Le Wan, Wen Xing He and Chang Yu Chen (2016) proposed a method of structural process design based on 3D model. The paper focused on designing a peculiar 3D assembly method meeting the demands of spacecraft. Firstly, an assembly digital mock-up (ADMU) was constructed. Second, they proposed the way of assembly process design on 3D structural process design scheme. Finally, the paper describes the application of the technology, and analyses the effect of the scheme during a satellite development. Furthermore, using uniform data source from assembly digital mock-up and analyzing two essential criteria about digitization assembling spacecraft, the solution was proposed for structured process design, working process and system framework about assembling spacecraft. Combined with the actual case demonstration it had a good application outcome.

Vladimir M. Petrovic, Dragan Zlatanovic, Mirko Borisov, Lidija Djurdjevac Ignjatovic (2016) described the concepts of 3D terrain models and their application in mining. Mining basins and open pit mines have a specific topography. Their features are sudden transition of relief features, both spatial and in time, which is interesting for analysis and interpretation of surveying data i.e. terrain modelling in function of time. Thereby available technology enables integration of different surveying instruments and technologies into single system, in order to obtain accurate and reliable information and to link those with operational efficiency. There is a need for frequent acquisition of profiles, calculation of earth volumes, review of maximal inclination, creation of future terrain interpretations and configuration, optical visibility and similarity. Having all this in mind, as well as frequent changes in terrain surface in time, the concept of digital terrain modelling provides large methodological and technological capabilities for research and execution of the mining activities.

Giacomo Landeschi, Björn Nilsson, Nicolo Dell'Unto(2016) focuses entirely on the amount of damage made by both the vehicle and the illegal metal detection. One of the main goals of this study was to test a heuristic approach towards the use of 3D GIS in the excavation practice. For this reason, three different phases of an archeologically excavation have been documented through a combined use of image-based 3D reconstruction techniques and GIS tools. The present research has sought to demonstrate how 3D models can be effectively used in field archaeology as a means for land evaluation and risk assessment. The rescue archaeology is the dominant form of field archaeology and there is a lot of work done with the purpose of legally protecting the cultural heritage. In this respect it becomes extremely important to benefit from the use of advanced quantitative methods that can provide archaeologists with a more objective insight into the situation observed in the field. Additionally, the adoption of formal methods of analysis and site evaluation that heavily rely on 3D as a further source of information should be included and fostered as an additional means for assessing those archaeological sites at risk of degradation or threatened by ongoing conflicts and wars.

Davis Dinkov, Rumiana Vatseva(2016) presented cartographic applications of 3D landscape modelling and visualization for tourist maps protected areas monitoring. The study was focussed on technical approaches for data modelling; cartographic design and practical use of the created 3D maps.3D landscapes were developed and visualized using specialized GIS software that allows modelling the real landscape in very high level of details. Various visualization techniques were illustrated for basic landscape features types and 3D cartographic symbols. The applied approach facilitated an attractive representation of 3D geovirtual

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environment and realistic visualization by 3D panoramic maps. It offered an effective means for visual communication of 3D spatial information. Creation of 3D models and 3D maps were generated at different levels of detail and generalization according to user demands. The whole mapping process is aimed at better understanding not only of the modelling techniques, but also of the end user requirements. This emphasized the high degree of customization with respect to cartographic design and applications. The present work highlights the need for more study to be done on the efficient presentation of geospatial information by providing additional context within a 3D maps.

Abdulla Al-Rawabdeh, Nadhir Al-Ansari, Hussain Attya and Sven

Knutsson(2014) discussed the concept of 3D GIS modeling techniques using a simple procedure to generate a university campus model which showed the effectiveness of this approach. The 3D GIS model provides access to mapping data to support planning, design and data management. The primary objective was to improve data management (e.g., maps, plans, usage of facilities and services) and to develop methods using 3D spatial analysis for specific applications at the university.3D GIS provides urban designers and planners with a useful tool for modeling and analysis. The 3D GIS application was developed in order to evaluate urban space efficiently and to provide information about urban planning to local communities. This application enables users to visualize complicated urban planning information in the 3D way, to evaluate the allowable capacity of the block and to stimulate building plans. With visualization and analysis capability, 3D GIS are considered a powerful tool to solve various issues which modern cities confront.

Rahul S. Jain, Pradhir D. Parmar, Dhruvesh P. Patel (2017) discussed all techniques and their usefulness in 3D city model creation from the GCP, base map, SRTM and QGIS. Planning and drawing is the important aspect of civil

engineering. For testing theories about spatial location and interaction between land uses and related activities the computer based solution of urban models are used. The planner's primary interest is in creation of 3D models of building and to obtain the terrain surface so that he can do urban morphological mappings, virtual reality, disaster management, fly through generation, visualization etc. This study was carried out to demonstrate a procedure for generating the 3D model of city using the master plan and the GCP points with the help of the open source software QGIS. With the rapid development of urban city, 3D models of city have become necessary to be generated to know the future development of the city. We believe that this research is important to the urban city planner, to generate the 3D model of city before constructing the city so as the effect of earthquake, flood, rain, etc. can be determined and accordingly preventive measures can be taken to reduce the loss due to them.

Fuzal Ahmed and K.Srinivasa Rao (2019) demonstrated the applicability of remote sensing, DEM data and GIS tools for basin analysis with reference to the tectonics. They studied about the Tuirini River that drains over an area of about 420 sq.km. The study shows that, most of the tributaries originate from the high altitude and show more or less straight courses due to the structural effect. The terrain is tectonically active as supported by the existence of number of lineaments, fractures and faults. Thus the study concluded that the remotely sensed data and DEM data coupled with GIS techniques recognized to be a competent tool in terrain analysis, which would be helpful in various development activities and conservation of natural resources of the basin area.

Kartik R. Kulkarni, Yatish C. H., Kiran P.Kamble, Ashish A.Kulkarni,Shashank C. Bangi(2017) worked on the campus of K.L.S Gogte Institute ofTechnology which is located in Udyambag Belagavi. The objective of this study was

to create the2D map and 3D model of the campus and to present the current status using the GIS concept. The aim of this project was to show how software's like google earth, SketchUp and QGIS can be used to represent 2D and 3D environment with more reliability, accuracy and less time. In this work the technique employed was simple and user friendly, time effective and cost effective. The technique employed in this study has given the good results with higher accuracy.

Edon Maliqi, Petar Penev, Faik Kelmendi (2017) aimed in developing the Digital Terrain Model (DTM) through QGIS software. They concluded that QGIS software was appropriate software for creating, analyzing, interpreting and visualization the DTM and geo-spatial data in general. It was easy for generating the DTM using this software. QGIS software supports some methods and techniques of generating DTM. In the paper are proved TIN and GRID methods and some of visualization techniques of DTM like contour lines, hillshading and perspective view. All methods and techniques have advantages and disadvantages between each other. A disadvantage of QGIS software was it does not allow/support improving of DTM created for example we cannot improve connection of triangles according logical way to TIN. Also it has some choices to visualize the DTM.

B. G. Kodge (2020) aimed to study the current scenario of COVID19 cases in Maharashtra state using the geo-visualization techniques. The paper deals with the district wise current situations showing through compiled maps of COVID19 cases and also presents the detailed ward wise map of COVID19 cases of Mumbai city which has the highest number of cases in Maharashtra state. The information was generated geographically and presented the covid status. The results provided in this paper are the evidences showing the current status of COVID19 cases in Maharashtra state of India. The infected cases were increasing on one side, on

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another side the numbers of recovered cases were also increasing. But at the same time the deceased cases were also increasing enormously. The results published in this paper are subject to change in due course of time.

Xun Shi, Lyndsey Girod, Robert Long, Roger DeKett, Jessica Philippe, Tom **Burke** (2012) compared the performance of Lidar-based DEM and the USGSsourced DEM in calculating slope gradient as an input for knowledge based digital soil mapping, aimed to provide scientific evidence and proposed a scientific approach to evaluate the two types of DEM for KBDSM. The findings of this study are summarized as follows: (1) In terms of matching the field-measured values, the LiDAR-based DEM performed considerably and consistently better than the USGSsourced DEM. Particularly, at the 30-m neighborhood, the "error" measured by MAE was reduced by about 50% when using LiDAR- based DEM.(2) In terms of matching the field-measured values, the results from the resampled 5-m LiDARbased DEM only differed slightly from those from the 1-m LiDAR-based DEM, and for the smaller neighborhood (10 m), the 5-m DEM even performed better than the 1m DEM.(3) On a smaller measuring neighborhood (10m), the mismatch between the DEM-based and the field-measured values are greater than that on a lager measuring neighborhood (30 m). (4) On a larger neighborhood, the methods using the circular neighborhood performed better than the methods using the conventional square neighborhood. (5) On gentle slopes, the DEM-based values tended to overestimate the field-measured values, whereas on steep slopes, the DEM-based values tended to underestimate the field-measured values, and 20% (slope gradient) seems to be the turning point. This study only tested one terrain attribute (although it is an important one in soil-landscape modeling) and only worked on one small watershed. The study found that the results from the 1-m LiDAR based DEM and the resampled 5-m DEM do not show considerable and consistent differences.

Anjali G Pillai, Ashna K N (2015) dealed with employing IDW interpolation techniques in carrying out precipitation interpolation of Kozhikode district in Kerala, India using QGIS and assessing the output to understand the general trend of rainfall pattern seen in that area. Rainfall maps of 2010 and 2014 were compared and overall decrease in the precipitation amount was observed. Further the use of QGIS software for carrying out this project further enables the promotion of this freeware. At reduced cost and with comparable efficiency the tasks can be performed very easily for obtaining appropriate outputs for various research oriented projects. The results of this project can be utilized for creating inputs for various hydrological models which can be considered as the suitable future scope of development.

Zhou Li, Sun Jia-long, Li Wei-xiao, Bai He, Chen Wei-wei (2008) discussed the object-oriented 3D modeling technique to use existing digital photogrammetric software platform for secondary development. The text includes: the object-oriented concept of 3D modeling; the 3D GIS modeling technology based on digital photogrammetry; the Digital Campus examples of 3D modeling over the current Digital Campus space modeling, using the methods of divide entities and management-oriented data modeling to combine the 3D model of the campus and the database management objectives, achieve the 3D model of the campus on the school's Information Management Services Digital and inquiry friendly the accurate information. This paper puts stress on discussing the inquiring for detail information of entity, however nowadays it is very difficult to skim in 3D model through the material inside of entity which will need more much time and great effort to deal with.

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3. STUDY AREA

Thoothukudi district is in the Indian state of Tamil Nadu. The city lies in the Coromandel Coast of Bay of Bengal. The study area is located at 8.53°N 78.36°E in South India, on the Gulf of Mannar, about 540 kilometres (340 miles) south of Chennai and 125 kilometres (78 miles) north of Kanyakumari. The hinterlands of the port of the city are connected to the districts of Madurai, Tirunelveli, Ramanathapuram and Tiruchirapalli.



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The city has a very high humidity being in the coastal sector. The topographic elevation of the watershed varies from 27.00 m (amsl) in the catchment area to few meters (amsl) near the coast and slopes from west to east. The slope is gentle in western and central parts and more or less plain in eastern part of the watershed. The area experiences semi-arid tropical climatic condition and the long term average annual rainfall is 568 mm. In Thoothukudi District Thamirabarani River, Vaippar River, and their tributaries are draining and passing through the District. The Thamirabarani river is perennial in nature. Thoothukudi district has consist of eight taluks such as Thoothukudi, Srivaikundam, Kovilpatti, Ettayapuram, Vilathikulam, Ottapidaram, Thiruchendur and Sathankulam) with total population of 17, 50,176 (as per 2011 census). The district is divided into 12 blocks for rural and urban development such as Tuticorin, Thiruchendur, Udangudi, Sathankulam, Srivaikundam, Alwarthirunagari, Karunkulam, Ottapidaram, Kovilpatti, Kayathar, Vilathikulam, and Pudur.

4. METHODS AND MATERIALS

4.1. QGIS

QGIS functions as geographic information system (GIS) software, allowing users to analyze and edit spatial information, in addition to composing and exporting graphical maps. QGIS supports raster, vector and mesh layers. Vector data is stored as point, line, or polygon features. Multiple formats of raster images are supported and the software can geo-refer images.



In this project we have used QGIS version 3.22.4 which includes a vast number of user experience enhancements and controls added to various advanced functionalities. In addition to a host of additional mesh functionality and operational improvements.

4.2. DATA COLLECTION

4.2.1. VECTOR DATA

Vector data provide a way to represent real world features within the GIS environment. Vector features have attributes, which consist of text or numerical information that describe the features. A vector feature has its shape represented using geometry. The geometry is made up of one or more interconnected vertices. A vertex describes a position in space using an X, Y and optionally Z axis.

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Select Layer > Add Layer > Add Vector Layer

The vector data was downloaded from the web page DIVAGIS. All the shape files were added to the QGIS software.

4.2.2. RASTER DATA

A raster layer consists of one or more raster bands — referred to as single band and multi band raster's. One band represents a matrix of values. Raster data is like any image. Although it may portray various properties of objects in the real world, these objects don't exist as separate objects; rather, they are represented using pixels of various different color values.

The raster data was downloaded as an individual tile from the website BHUVAN and was added in the QGIS.

Select Layer > Add Layer > Add Raster Layer

A digital elevation model is a bare-earth raster grid referenced to a vertical datum. The non-ground points such as built (power lines, buildings and towers) and natural (trees and other types of vegetation) aren't included in a DEM.



MERGE

The raster tiles downloaded from BHUVAN is merged in QGIS. The merge layers tool merges features from multiple layers into a single shape file and adds the merged shape file to the project.

Select Raster > Miscellaneous > Merge.

MASK

Masking is a technique used to clarify dense or detailed map content by having the features of one layer hide, or mask, features of another layer where they overlap.

Select Raster > Extraction > Clip Raster by Mask Layer

4.3. TERRAIN ANALYSIS

4.3.1. ASPECT

Aspect is the compass direction that a slope faces. The pixels will have a value from 0-360 degrees measured in degrees from north indicating the azimuth. Aspect values indicate the directions the physical slopes face. We can classify aspect directions based on the slope angle with a descriptive direction. An output aspect raster will typically result in several slope direction classes. Aspect identifies the down slope direction of the maximum rate of change in value from each cell to its neighbors. Aspect can be thought of as the slope direction. The values of the output raster are the compass direction of the aspect. Aspect is measured counterclockwise in degrees from 0 (due north) to 360(again due north, coming full circle). The value of each cell in an aspect grid indicates the direction in which the cell's slope faces. Flat slopes have no direction and are given a value of -1. An aspect-slope map simultaneously shows the aspect (direction) and degree (steepness) of slope for a terrain (or other continuous surface). The values of the output raster will be the compass direction of the aspect, represented by a hue (color).

Parameters

Label	Name	Туре	Description
Input layer	INPUT	[raster]	Input elevation raster layer

Band number	BAND	[raster band] Default: 1	The number of the band to use as elevation
Return trigonometri c angle instead of azimuth	TRIG_AN GLE	[boolean] Default: False	Activating the trigonometric angle results in different categories: 0° (East), 90° (North), 180° (West), 270° (South).
Return 0 for flat instead of -9999	ZERO_FL AT	[boolean] Default: False	Activating this option will insert a 0-value for the value -9999 on flat areas.

4.3.2. HILL SHADE

Hill shading is a technique for visualizing terrain determined by a light source and the slope and aspect of the elevation surface. The hill shade function produces a grayscale 3D representation of the terrain surface, with the sun's relative position taken into account for shading the image. It is a technique where a lighting effect is added to a map based on elevation variations within the landscape. A hill shade can provide very useful information about the sunlight at a given time of day. But it can also be used for aesthetic purposes, to make the map look better. The key to this is setting the hill shade to being mostly transparent. Hill shading is a technique used to create a realistic view of terrain by creating a three-dimensional surface from a two-dimensional display of it. Hill shading creates a hypothetical illumination of a surface by setting a position for a light source and calculating an illumination value for each cell based on the cell's relative orientation to the light, or based on the slope and aspect of the cell. The hill shade layer contains values from 0 (complete shadow) to 255 (complete sun). Hill shade is used usually to better understand the relief of the area.

Parameters

LABEL	NAME	TYPE	DESCRIPTION
Elevation layer	INPUT	[raster]	Digital Terrain Model raster layer
Z factor	Z_FACTOR	[number] Default: 1.0	Vertical exaggeration. This parameter is useful when the Z units differ from the X and Y units, for example feet and meters. You can use this parameter to adjust for this. Increasing the value of this parameter will exaggerate the final result (making it look more "hilly"). The default is 1 (no exaggeration).
Azimuth (horizontal angle)	AZIMUTH	[number] Default: 300.0	Set the horizontal angle (in degrees) of the sun (clockwise direction). Range: 0 to 360. 0 is north.
Vertical angle	V_ANGLE	[number] Default:	Set the vertical angle (in degrees) of the sun, that is the height of the sun. Values can

Parameters

LABEL	NAME	TYPE	DESCRIPTION
		40.0	go from 0 (minimum elevation) to 90 (maximum elevation).
Hill shade	OUTPUT	[raster]	 Specify the output hill shade raster layer. One of: Save to a Temporary Layer (TEMPORARY_OUTPUT)) Save to File The file encoding can also be changed here.

4.3.3. SLOPE

A slope map is a topographic map showing changes in elevation on a highly detailed level. Architects, landscape designers, and water control planners use a slope map to evaluate a particular site. Slope is the angle of inclination to the horizontal. The slope tool identifies the steepness at each cell of the raster surface. The lower the slope value, the flatter the terrain; the higher the slope value, the steeper the terrain. Detailed data are required to generate one of these maps. In QGIS this tool can be found under 'Raster'-> 'Terrain Analysis'-> 'Slope', in the menu bar at the top. As input it requires our DEM raster file. The slope of any line remains constant along the line. The slope tells the information about the direction of the line on the coordinate plane. It is important for the farmer or irrigator to identify the slopes on the land. A slope is easy to recognize in a hilly area.

Parameters

Label	Name	Туре	Description
Input layer	INPUT	[raster]	Input Elevation raster layer
Band number	BAND	[raster band] Default: 1	Band containing the elevation information
Ratio of vertical units to horizontal	SCALE	[number] Default: 1.0	The ratio of vertical units to horizontal units
Slope expressed as percent (instead of degrees)	AS_PERC ENT	[boolea n] Default: False	Express slope as percent instead of degrees
Compute edges	COMPUTE _EDGES	[boolea n] Default: False	Generates edges from the elevation raster

Use Zevenbergen&Thorn e formula (instead of the Horn's one)	ZEVENBE RGEN	[boolea n] Default: False	Activates Zevenbergen&Thor ne formula for smooth landscapes
Slope	OUTPUT	[raster] Default: [Save to tempora ry file]	Specify the output raster layer. One of: • Save to a Temporar y File • Save to File

4.3. 4.SIEVE

'Sieve' is a constraints and opportunities mapping process that builds up a number of geographical layers to produce a visual presentation of areas that show less(or more) potential for future settlement growth. The process of 'Sieve Mapping' as a planning tool, indicating that it 'constituted a most valuable means of summarizing and analysis survey data'. These maps are overlain on a base map and on each other to reveal areas not subject to any constraints. Using overlays rather than redrawing all the constraints on a single composite map has the advantage that overlays can be used in any combination. Sieve removes polygons smaller than a provided threshold size (in pixels) and replaces them with the pixel value of the largest neighbor polygon. It is useful if we have a large amount of small areas on our raster map.

Parameters

Label	Name	Туре	Description
Input layer	INPUT	[raster]	Input elevation raster layer
Threshold	THRESHOLD	[numbe r] Default : 10	Only raster polygons smaller than this size will be removed
Use 8- connectednes s	Use 8- connectednes s		Use eight connectedness instead of four connectedness
Do not use the default validity mask for the input band	NO_MASK	[boolea n] Default	

		: False	
Validity mask Optional	MASK_LAYER	[raster]	Validity mask to use instead of the default
Sieved	OUTPUT	[raster] Default : [Save to tempor ary file]	Specify the output raster layer. One of: • Save to a Temporary File • Save to File

4.3.5. CONTOUR

Contour is a height isoline. Isoline is a line on a map with a constant value. Therefore the contour definition is a line which has a constant elevation along the line. There are some characteristics of contour line such as contour interval, contour elevation and distance between contour lines. A contour map has many lines on it. Those lines are never crossing to each other and each line has a unique elevation value that defines its elevation on the map. Contour interval defines height interval between the lines.

4.3.6. RELIEF

Relief (or local relief) refers specifically to the quantitative measurement of vertical elevation change in a landscape. It is the difference between maximum and minimum elevations within a given area, usually of limited extent. Relief is essentially the opposite of "flatness". It is the difference in height between the high point and the low point on a landscape, in feet or in meters. Various features like mountains, hills, plateaus and plains are found on the earth's surface. Elevations and depressions on the earth's surface are known as the relief features of earth. Creates a shaded relief layer from digital elevation data. You can specify the relief color manually, or you can let the algorithm choose automatically all the relief classes.

Label	Name	Туре	Description
Elevation layer	INPUT	[raster]	Digital Terrain Model raster layer
Z factor	Z_FACTO R	[number] Default: 1.0	Vertical exaggeration. This parameter is useful when the Z units differ from the X and Y units, for example feet and meters. You can use this parameter to adjust for this. Increasing the value of this parameter will exaggerate the final result

Parameters

Label	Name	Туре	Description
			(making it look more "hilly"). The default is 1 (no exaggeration).
Generate relief classes automati cally	AUTO_CO LORS	[boolean] Default: False	If you check this option the algorithm will create all the relief color classes automatically
Relief colors Optional	COLORS	[table widget]	Use the table widget if you want to choose the relief colors manually. You can add as many color classes as you want: for each class you can choose the lower and upper bound and finally by clicking on the color row you can choose the color thanks to the color widget.

Label	Name	Туре	Description
			The buttons in the right side panel give you the chance to: add or remove color classes, change the order of the color classes already defined, open an existing file with color classes and save the current classes as file.
Relief	OUTPUT	<pre>[raster] Default: [Save to tempor ary file]</pre>	Specify the output relief raster layer. One of: • Save to a Temporary Layer (TEMPORARY _OUTPUT) • Save to File The file encoding can also be changed here.

5. RESULT AND DISCUSSION

With the help of DEM image from Bhuvan we worked on creating different features such as aspect, hill shade, slope, sieve, relief and contour of Tuticorin Taluk.

5.1. CALCULATING THE TERRAIN ANALYSIS FEATURES

5.1.1. ASPECT

We obtained aspect of Tuticorin district by the following methods:

- Raster > Analysis > Aspect
- In the dialog that appeared, we ensured that the input file was DEM layer.
- We have set the output file to aspect.tif in the directory exercise _ data / residential _ development.
- When the processing was complete we got a new layer called aspect.
- We changed the symbology of the original DEM to use the pseudocolour scheme
- Hid all the layers except the DEM and aspect layers.
- Clicked and dragged the DEM to be beneath the aspect layer in the Layers list.
- We set the aspect layer to be transparent by opening its Layer properties and we set the transparency to 0%
- View > New 3D Map View
- In scene setting, we had set the z-exaggeration to 50
- We got the result like this:



5.1.2. HILL SHADE

We obtained hill shade of Tuticorin district by the following methods:

- Raster > Analysis > Hill shade
- In the dialog that appeared, we ensured that the input file was DEM layer.
- We have set the output file to hillshade.tif in the directory exercise _ data / residential _ development.
- When the processing was complete we got a new layer called hill shade.
- We changed the symbology of the original DEM to use the pseudocolour scheme
- Hid all the layers except the DEM and hill shade layers.
- Clicked and dragged the DEM to be beneath the hill shade layer in the Layers list.
- We set the hill shade layer to be transparent by opening its Layer properties and we set the transparency to 0%
- View > New 3D Map View

- In scene setting, we had set the z-exaggeration to 50
- We got the result like this:



5.1.3. SLOPE

We obtained the slope of Tuticorin district by the following methods:

- Raster > Analysis > Slope
- In the dialog that appeared, we ensured that the input file was DEM layer.
- We have set the output file to slope.tif in the directory exercise _ data / residential _ development.
- When the processing was complete we got a new layer called slope.
- We changed the symbology of the original DEM to use the pseudocolour scheme
- We set the slope layer to be transparent by opening its Layer properties and we set the transparency to 0%

- View > New 3D Map View
- In scene setting, we had set the z-exaggeration to 50
- We got the result like this:



5.1.4. SIEVE

We obtained the sieve of Tuticorin district by the following methods:

- Raster > Analysis > Sieve
- In the dialog that appeared, we ensured that the input file was DEM layer.
- We have set the output file to sieve.tif in the directory exercise _ data / residential _ development.
- When the processing was complete we got a new layer called sieve.
- We changed the symbology of the original DEM to use the pseudocolour scheme
- We set the sieve layer to be transparent by opening its Layer properties and we set the transparency to 0%
- View > New 3D Map View

- In scene setting, we had set the z-exaggeration to 50
- We got the result like this:



5.1.5. CONTOUR

We obtained the contour of Tuticorin district by the following methods:

- Raster > Analysis > Contour
- In the dialog that appeared, we ensured that the input file was DEM layer.
- We have set the output file to contour.tif in the directory exercise _ data / residential _ development.
- When the processing was complete we got a new layer called contour.
- We changed the symbology of the original DEM to use the pseudocolour scheme
- We set the contour layer to be transparent by opening its Layer properties and we set the transparency to 0%
- We got the result like this:

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RELIEF

We obtained the relief of Tuticorin district by the following methods:

- Raster > Analysis > Relief
- In the dialog that appeared, we ensured that the input file was DEM layer.
- We have set the output file to relief.tif in the directory exercise _ data / residential _ development.
- When the processing was complete we got a new layer called relief.
- We got the result like this:



5.2. APPLICATION

COVID CASE TABLE

Here are the ten states with the highest daily spikes in Covid-19 cases in India:

STATE	POSITIVE CASES
Maharashtra	66,191
Uttar Pradesh	35,311
Karnataka	34,804
Kerala	28,469
Delhi	22,933
West Bengal	15,889
Rajasthan	15,809
Tamil Nadu	15,659
Gujarat	14,296
Madhya Pradesh	13,601

Geographic information science (GIS) has established itself as a distinct domain and incredibly useful whenever the research is related to geography, space, and other spatio-temporal dimensions. However, the scientific landscape on the integration of GIS in COVID-related studies is largely unknown. In this systematic review, we assessed the current evidence on the implementation of GIS and other geospatial tools in the COVID-19 pandemic.

Understanding the spatiotemporal dynamics of COVID-19 is essential for its mitigation, as it helps to clarify the extent and impact of the pandemic and can aid decision making, planning and community action. We obtained the COVID_19 affected total case strategies in India from Wikipedia and organized the data in the excel sheet. The sheet is saved in the CVS data format. In the QGIS software, the vector layer downloaded from DIVAGIS is used.

- Layer > Data Source Manager > Delimited Text > Add CSV file
 1. geometry definition no geometry
- Layer panel > Cases Layer > properties > Joints > Add New Joint.
- Join layer Cases, join field state, target field state in vector layer > apply.
- The cases are added to the attribute table of the vector layer.
- The vector layer is exported to make it as the permanent layer.
- To categories the Covid case, properties > symboloy > categorized > value cases > apply.
- Properties > label > single label.
- We got the result like this



The interdisciplinary nature of how geographic and spatial analysis was used in COVID-19 research was notable. This application not only provided an overarching view on how GIS has been used in COVID-19 research so far but also concluded that geospatial analysis and technologies could be used in future public health emergencies along with statistical and other socio-economic modeling techniques. Our review also highlighted how scientific communities and policymakers could leverage GIS to extract useful information to make an informed decision in the future. Despite the limited applications of GIS in identifying the nature and spatio-temporal pattern of this raging pandemic, there are opportunities to utilize these techniques in handling the pandemic. The use of spatial analysis and GIS could significantly improve how we can understand the pandemic as well as address the underserviced demographic groups and communities.

6. CONCLUSION

Remote sensing and Terrain analysis using Quantum GIS techniques is a powerful tool for mapping and evaluating different features of land. We created different features of Tuticorin Taluk such as aspect, hill shade, slope, sieve, contour and relief from the DEM images downloaded from Bhuvan. This study classifies terrain features of Tuticorin using DEM from Bhuvan website through Quantum Digital Elevation Model. We obtained 3D model of all the terrain features from the study. This study is useful because it can handle the complexity of individual landscape processes and patterns as well as some of the difficulties that are encountered in delineating the appropriate spatial and temporal scales. This application not only provided an overarching view on how GIS has been used in COVID-19 research so far but also concluded that geospatial analysis and technologies could be used in future public health emergencies along with statistical and other socio-economic modeling techniques. Our review also highlighted how scientific communities and policymakers could leverage GIS to extract useful information to make an informed decision in the future. Despite the limited applications of GIS in identifying the nature and spatio-temporal pattern of this raging pandemic, there are opportunities to utilize these techniques in handling the pandemic. This study may help the Government to evaluate the total cases and can keep the pandemic situation under control.

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